JOURNAL OF DAIRY SCIENCE

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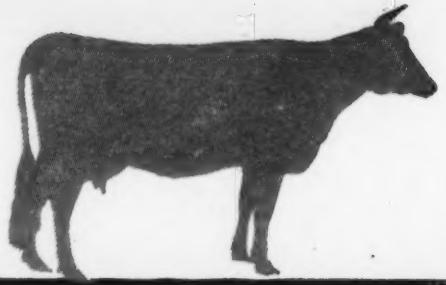

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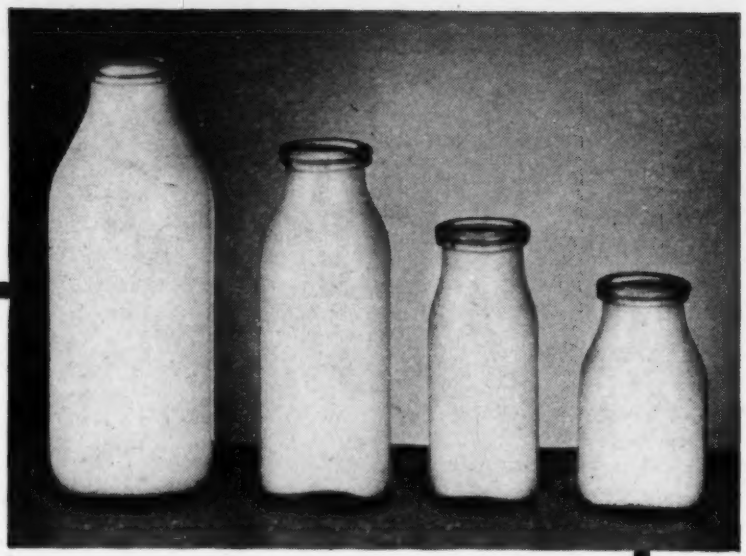

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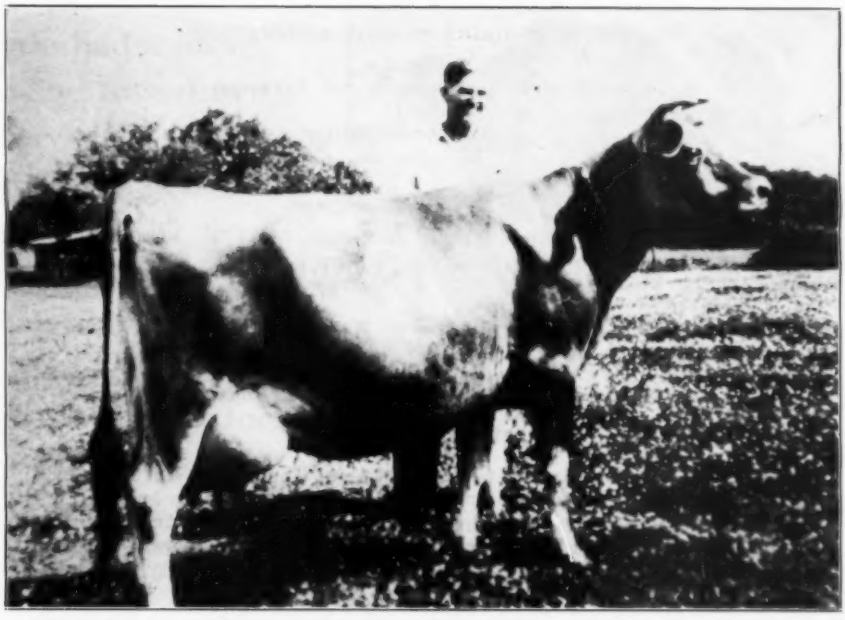

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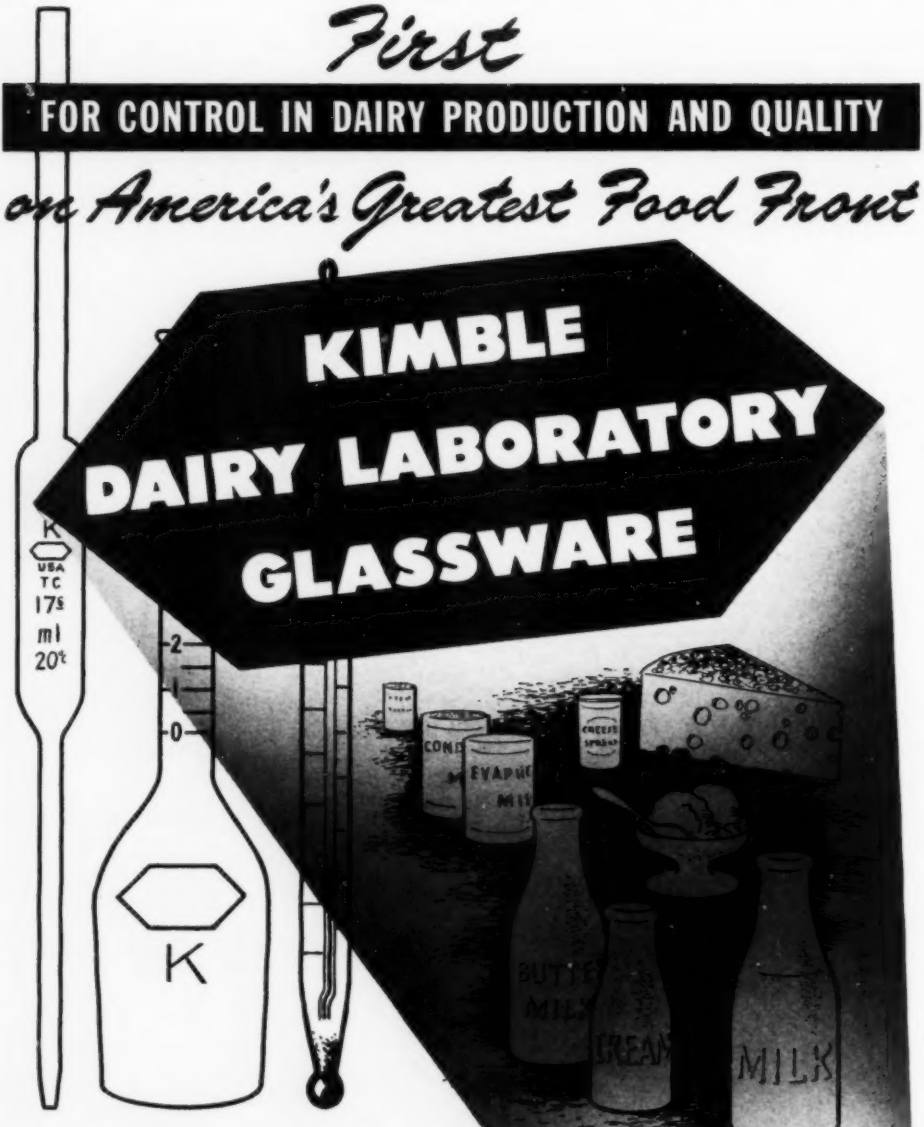

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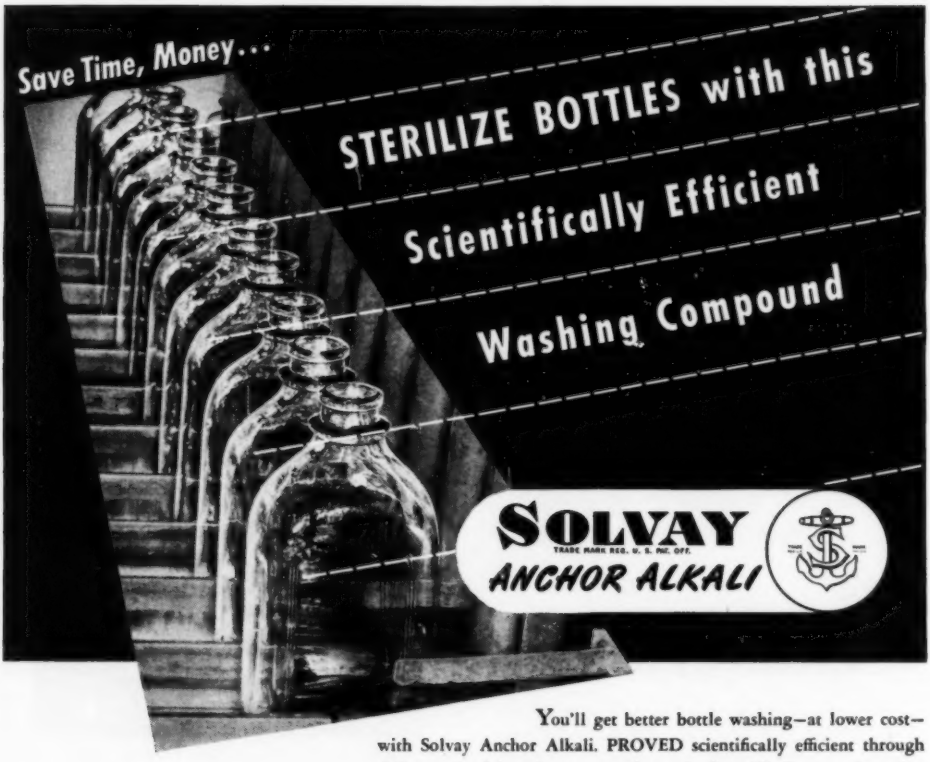

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VOLUME XXVIII MARCH, 1945 NUMBER 3

A COMPARISON OF SAMPLING PROCEDURES IN MAKING PASTURE YIELD DETERMINATIONS

W. B. NEVENS

Illinois Agricultural Experiment Station, Urbana

The sampling method of computing yields of pasture herbage is advantageous because of its simplicity, speed with which results are obtained, and the availability of the samples for chemical analyses. Some investigators, however, maintain that the measurement of pasture forage is obtained ultimately by grazing trials and that the most critical measurement of the yield of a pasture is the amount and quality of herbage cattle remove from it. It is granted that records of milk production, gain in live weight, and other data from grazing experiments are valuable, but there are situations where these data are incomplete when dealing with the yield of individual pastures. Such a situation is a part of the pasture project from which the data reported in this paper were obtained, namely, a rotation plan of pasturing, in which a number of different pasture crops were used and the cattle were shifted from one field to another at intervals of seven to fourteen days. A number of errors may enter into cattle data, such as inability to adjust the number of animal units to marked changes in the amounts of available forage and the employment of assumed digestibility coefficients which may or may not be applicable to forage which undergoes pronounced changes in its chemical composition with changes in rainfall and with advancing development of the plants. Hence, it is desirable that yields obtained by some dependable method of harvesting accompany grazing tests.

The worth of a pasture crop is dependent upon its conversion into animal products of use to man. Yields obtained through sampling procedures should tend to approach the animal production values obtained in well-managed grazing trials.

The yield determinations made by the sampling method are subject to a number of possible errors and limitations, depending upon the procedure used. Errors of considerable magnitude may occur because of the relatively small areas harvested and the large factors which must be used in converting the yields of sample areas to an acre basis. Errors of judgment in selecting the portions of a field or crop to be sampled are unavoidable. It has been

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shown, however, that good comparative values are obtained when the method is employed by experienced operators. The "direct harvest" procedure in sampling, as later described, is not suitable for use with crops such as sweet clover and soybeans, which are killed by repeated close harvesting, and has a restricted application to pasture crops which recover slowly from close clipping. The height at which upright and decumbent forages should be harvested requires judgment based on observation and experience. The "difference" plans overcome some limitations of the direct harvest procedure and provide a valuable check on it, but are in themselves subject to criticisms. The purpose of this paper is to compare these sampling procedures and to point out their advantages and limitations.

REVIEW OF LITERATURE

Wide differences occur in the sampling procedures employed in pasture investigations. Field mowers, lawn mowers with grass catchers, hand sickles, grass shears, and hand plucking are used in harvesting various types of pasture herbage. Protected sampling areas range from fenced areas one or more square rods in size to cage-covered areas measuring only a few square feet. Frequency of harvesting the sampling areas ranges from weekly to once or twice yearly. Height of cutting ranges from one to two inches up to the height left by cattle after grazing.

Ahlgren and associates (1, 2) employed a cage and clipping procedure in which the forage beneath each cage was cut at a height approximately equal to that left by the cattle in the grazed portion of the pasture at the end of each grazing period. The cages were then moved to new areas taken at random. Untreated pastures were sampled only twice during the season.

Bartlett (4) found experimental errors due mainly to plot variation, and little advantage was gained from duplicate sampling of harvested forage.

Brandt and Ewalt (5) obtained satisfactory yield determinations both from the grazing of dairy cows and from stationary ungrazed clip plots, although the clip plot method gave larger values.

Brown (6) concluded, as a result of his extensive pasture investigations, that "the clipping of caged areas does afford a reasonably accurate method of determining the productivity of fenced pastures varying only in one of such factors as soil type, direction of slope, or botanical composition." He found that continuously clipped cages yielded less than annually moved cages.

Gardner *et al.* (9) reported a consistent relationship between the yield of clippings and grazing yield data. Hay and aftermath yields were always larger than clipping yields.

Hodgson *et al.* (10, 11) obtained through a clipping procedure dry-matter yields which varied considerably from season to season and which lacked a consistently uniform relationship with yields as determined by

grazing trials. In another investigation, the nutrient yields of pastures were calculated from digestibility determinations of samples clipped from grazed and cage-protected areas at the end of each grazing period. The difference in yield from the protected and grazed areas was assumed to be the amount consumed. The total digestible nutrient yields determined in this manner were found, as an average of five years trials, to be 127 $\pm$ 10.5 per cent of those computed from concurrent grazing trials with dairy cows.

Jones, Ewalt, and Haag (12) found clip plot yield determinations higher than returns calculated from the production of dairy cows.

Klingman, Miles, and Mott (13) studied the precision obtained with various sampling procedures and among a number of operators. They found the difference plan of measuring consumption advantageous over the direct harvest procedure in that growth conditions within the cage more nearly represent the grass under actual grazing conditions. In using the difference plan, it was more efficient to choose one unit at random and a second similar to the first than to choose both at random. They point out that, because operators differ in their work, it is necessary that they be properly directed.

Morgan and Beruldsen (14), in an extensive study of experimental techniques, computed from clipping data the quantity of herbage consumed during grazing as the amount present before grazing less that at the close of the period plus the amount of growth during grazing.

Ritchey and Henley (19) found a more nearly correct picture of the yields of a decumbent grass (centipede grass, *Eremochloa ophiuroides* (Mumo) Hack) was obtained by plucking than by clipping.

Robinson, Pierre, and Ackerman (20) employed permanent plots clipped five to six times yearly. They also used the difference plan of sampling in which open pasture yields were subtracted from protected area yields of the same date. They obtained a high correlation between yields measured by grazing and by clipping permanent plots. These clipping yields, however, showed a progressive decrease from year to year.

Schuster (21) recommends that cages be moved to grazed areas several times each season.

Woodward, Shepherd, and Hein (23) suggest that great care must be used in measuring the yields of hand-harvested caged areas, and that harvesting at short intervals gives lower annual yields than infrequent harvesting.

SAMPLING PROCEDURES

The sampling procedures used at the Illinois Station for the determinations of pasture yields have been described in detail in earlier publications (7, 8, 15, 16). The general plan is in substantial accord with the one recommended in the joint committee report of three scientific societies (3). Since the present discussion is primarily concerned with techniques of sampling, a brief review is given of the procedures used in obtaining the data herewith presented.

Direct harvest procedure. Just prior to turning the cattle to pasture, a sample of herbage was taken from an unprotected area of each experimental field. A metal cage about 4′ × 4′ square and 2′ high was placed over each harvested portion, and the herbage from these protected areas was harvested approximately one month later. At each harvest date the cages were moved to new locations, these being the cage-protected and freshly-harvested areas which provided one of the samples for the difference procedures described below. Moving to a new location after obtaining the direct harvest sample is necessary, since continued harvesting of the same area is likely to retard growth or to cause burning of the herbage and result in low yield figures. Each of the samples taken in the direct harvest procedure (with the exception of the first, which included growth up to that time) represented only the production of new-growth herbage since the preceding sampling date. The sum of these samples, calculated to an acre basis, constitutes the computed yield for the season.

Difference plans. The first sample of the season, taken just before the cattle were turned to pasture, served for both the direct harvest and difference plans. At the time this sample was taken, a wire cage was placed over a representative area of pasture. At regular intervals (in most cases monthly) thereafter, two samples were taken at each location, one from beneath the cage and the other from unprotected pasture. The cage was then moved a short distance to cover representative and not previously sampled forage. Difference plan No. 1 consists of subtracting the yield figure obtained from the open, or unprotected, pasture sample from the yield value of the cage-protected sample of the same date. In difference plan No. 2, the yield figure for each period is obtained by subtracting from the protected area yield figure the open pasture yield figure for the previous sampling date. This plan takes into account the growth occurring between these dates of harvest. Difference plan No. 3 is the same as the No. 2 plan except that the figure for residual herbage remaining at the end of the season is added.

Character of the pastures. The pastures which formed the basis for these studies were located on tillable land comprised of Drummer clay loam, and Brenton, Catlin, and Flannagan silt loams, soil types which rate relatively high among Illinois soils in productivity. The bluegrass pastures were well sodded with Kentucky bluegrass (*Poa pratensis* L.) and had been used as pasture for a number of years prior to the beginning of these studies. The bromegrass (*Bromus inermis* Leyss) was practically a pure stand. Fields 1, 2, and 5 were 4.5 acres in size, and fields 6a, 6b, and 7a were each 2.25 acres in area. Fields 5 to 7a, inclusive, adjoined each other and were originally one field. All received the same management treatments, including frequent applications of barnyard manure and the removal of large weeds, such as sour dock, by hand. Plots 0, 1, 2, 3, and 4 were each 2 × 2 rods in

size and were laid out within field 5. The plots were marked by short posts but were not fenced. These small plots were treated with cow urine.

Taking and caring for samples. The harvesting of the samples was accomplished by first laying on the ground an iron frame, 44 × 44 inches in area and 1½ inches high. A flat iron bar was moved across the frame to guide the grass shears used in clipping the sample (18). Some precaution such as this is necessary to insure uniformity in cutting the samples, particularly with low-yielding grass pastures such as bluegrass during the dormant season (July and August). Without such guides, or precautions, the variability in the harvesting of a single sample may cause a difference in the yield figure for that period of as much as 50 per cent. The samples were taken to the laboratory where they were carefully sorted into grass and weed portions. Usually the entire sample was dried, but occasionally reduction in size was necessary in order to promote drying. Each portion was placed in a tared cloth sac and dried in a thermostatically-controlled and electrically-heated oven at a temperature of 92 to 100° C. for 48 hours.

Grazing tests. That portion of the grazing data dealing with the continuous and with the alternate grazing of bluegrass pastures is included here in order to compare the two methods of yield determination, namely, yields found by grazing trials and yields obtained by sampling procedures. The other crops were grazed at such short intervals that determination of grazing yields of individual crops was impossible, and the data therefore were reported in terms of annual production from the entire rotation system (17).

Yearling heifers of the five dairy breeds were used in the grazing trials. The length of the grazing season ranged from 90 to 170 days and was determined by visual estimates of the adequacy of the forage to support animal gains. Nothing of nutritive value other than pasture, salt, and water was supplied. Live weights were taken on three successive days just before the heifers were turned to pasture and every four weeks thereafter while at pasture.

The cattle were taken from pasture in time to permit the grass to make a good ground cover. This residual forage was not accounted for by the grazing tests. Observations, as well as experimental data, indicate that late fall growth is needed for the restoration of plant reserves, and for the protection of the sod from wind and water erosion and from excessive freezing and thawing. This management practice undoubtedly contributes to the productivity of the pasture in succeeding years and should be regarded as a justifiable and acceptable procedure in grazing trials. Hence, the residual forage determined by sampling procedures at the close of the grazing season should not be included as a part of the forage yield.

Continuous grazing was practiced in field 5 for the entire period, and fields 6a and 6b from 1940 to 1942, inclusive. Fields 6a and 6b were grazed alternately at two-week intervals in 1937, 1938, and 1939. Fields 1, 2, and 7a were included in rotation systems of grazing.

DISCUSSION OF RESULTS

The sampling data obtained from bluegrass pastures on fields 5, 6a, 6b, and 7a over a six-year period, and from plots 1, 2, 3, and 4 within field 5 over a four-year period, were selected as a basis for the main part of this study.

TABLE 1

Comparison of "direct harvest" and "difference" plans of sampling in determining the yields of bluegrass pasture fields

Pounds of dry matter per acre

Field No.	Year	Direct harvest plan	Difference plan No. 1	Difference plan No. 2	Difference plan No. 3
5	1937	2692	2836	2374	2576
	1938	4032	2811	2365	2632
	1939	3062	2365	2722	3597
	1940	3151	2738	2576	2835
	1941	3142	3954	4052	4571
	1942	4264	4910	4522	4814
6a	1937	2681	3643	3306	3520
	1938	4341	4965	4754	5450
	1939	3371	3037	2859	3233
	1940	3267	3171	3198	3554
	1941	3870	3629	3711	4311
	1942	4607	4560	4334	3751
6b	1937	3232	4320	3281	3443
	1938	3612	5687	5817	6384
	1939	2641	2251	2260	2706
	1940	2445	1592	1673	2029
	1941	3661	3047	2674	2917
	1942	4175	3687	3427	3637
7a	1937	2440	2192	1956	2142
	1938	5202	3983	3464	3659
	1939	1970	3299	3250	3526
	1940	2982	3856	4117	4571
	1941	3663	3793	3696	4409
	1942	4801	3314	2764	2805
Mean		3471 ± 113	3485 ± 134	3298 ± 134	3628 ± 143
Standard error		821 ± 80	972 ± 95	969 ± 94	1041 ± 101
Coefficient of variability		23.7	27.9	29.4	28.7
Variance between years					
F value found		11.32	2.48	1.62	1.44
Required 5%		2.77	2.77	2.77	2.77
Required 1%		4.25	4.25	4.25	4.25
Variance between fields					
F value found		4.31	3.75	2.36	3.25
Required 5%		8.66	8.66	8.66	8.66
Required 1%		26.69	26.69	26.69	26.69

Kentucky bluegrass is well suited to comparison of sampling procedures since it responds well with renewed growth after close cutting, and is resistant to tramping, to destruction by drouth, and to winterkilling. The data (tables 1 and 2) show variations in yield from season to season on the same

field or plot and also differences in the seasonal yields as computed by the three plans. Yields determined by the direct harvest procedure in these trials had the smallest standard errors and the lowest coefficients of variation. A test of the variance of the yields was made following the procedure outlined by Snedecor (22). An F value of 11.32 for variance of the yields as between years was found for the direct harvest plan (table 1). This is a highly significant indication of variance at both the 5 per cent and at the 1 per cent level. This finding is in accord with experience and with the expectancy of changes in yield from year to year, and also in accord with the determined average yields which ranged from 2,761 pounds per acre in 1939 to 4,462 pounds in 1942. None of the difference plans of computing yields show a significant F value for variance between years.

A test of variance between fields (table 1) gives F values too low to be significant. Such a finding is a reasonable expectation since these adjoining fields were originally one, and all received nearly the same treatment. A significant variance in yields between plots was found for the fertilized plots but with the direct harvest plan only (table 2). These plots, Nos. 0, 1, 2, 3, and 4, were treated with quantities of cow urine in proportions of 0, 1, 2, 3, and 4, respectively; and yields were increased roughly in proportion to the amounts of fertilizer applied (15). An F value showing significant variance between these plots would be expected; and the fact that this was found for the direct harvest plan, but not for the difference plans, indicates that the direct harvest plan reflects more accurately than the other plans a correct picture of the yields.

Correlation values were computed for the yields as determined by the four plans. The results were as follows: For the direct harvest plan and difference plan No. 1 of tables 1 and 2, $r = +0.52$ and $r = +0.47$, respectively; for the direct harvest plan and difference plan No. 2 of the same tables, $r = +0.42$ and $r = +0.39$ respectively; for the direct harvest plan and difference plan No. 3, $r = +0.32$ and $r = +0.42$. The correlations between the direct harvest yields and difference plan No. 1 yields, as given in tables 1 and 2, and the correlation between the direct harvest yields and difference plan No. 2 yields of table 1, where $r = +0.42$, appear to be significant as judged by Fisher's tabular levels of significance; but the remainder are below the required 5 per cent level. A study of the correlation values of these sampling plans seems to be an unsatisfactory criterion of their relative value, possibly because of too small a number of observations.

The coefficients of variability for the eight groups of data in tables 1 and 2 range from 19 to 30, the smallest values being those for the direct harvest plan, with an average for the eight groups of about 27. It appears from these figures that any one of the four plans of calculating total seasonal yields may satisfactorily be used for bluegrass pastures and presumably for the yields of other grass pastures which have the resistance and recovery-

from-cutting characteristics of bluegrass. As judged by these studies, determinations of yield by the sampling method will have an expected error of 20 to 30 per cent.

In the calculation of yields of bluegrass and similar grass pastures by sampling periods, the direct harvest plan gives the most nearly correct pic-

TABLE 2

Comparison of "direct harvest" and "difference" plans of sampling in determining the yields of fertilized bluegrass pasture plots

Pounds of dry matter per acre

Plot No.	Year	Direct harvest plan	Difference plan No. 1	Difference plan No. 2	Difference plan No. 3
0	1939	2576	2466	2852	3759
	1940	2186	1524	1557	1946
	1941	2850	2268	2446	3029
	1942	3403	3766	3709	4065
1	1939	3304	4358	4245	4731
	1940	3499	3110	2961	3253
	1941	4045	1603	1895	2608
	1942	4197	3339	3258	3501
2	1939	3229	3742	3136	3152
	1940	3807	4472	4261	4293
	1941	4534	4239	4223	4579
	1942	4114	3499	3434	3661
3	1939	3743	5054	4471	4536
	1940	3563	4651	4732	4926
	1941	3857	3676	3741	4162
	1942	4519	3216	3126	3402
4	1939	4602	4649	4002	4067
	1940	4260	2736	2608	2704
	1941	4842	4080	3498	3626
	1942	4370	5232	5185	5400
Mean		3775 ± 107	3584 ± 160	3467 ± 141	3770 ± 130
Standard error		708 ± 76	1066 ± 113	935 ± 100	859 ± 92
Coefficient of variability		18.7	29.7	26.9	22.8
Variance between years					
F value found		1.17	1.36	1.86	1.68
Required 5%		3.24	8.69	8.69	8.69
Required 1%		5.29	26.83	26.83	26.83
Variance between plots					
F value found		8.16	2.63	1.79	1.11
Required 5%		3.06	3.06	3.06	5.86
Required 1%		4.89	4.89	4.89	14.19

ture period by period regardless of the intensity of grazing, while the difference plans are less reliable. The figures in table 3 show 1943 yields of adjoining fields having nearly pure stands of bromegrass. The data are for dry matter yields exclusive of weeds. The direct harvest plan shows large yields for the period April 21 to May 22, and declining yields period by period for the remainder of the season. The 1943 season was characterized by heavy rainfall in spring followed by comparatively low rainfall for the remainder

of the season. The direct harvest figures agree with normal expectancy in the yields of grass pastures in such a season. On the other hand, difference plan No. 1 shows a comparatively small yield for the first period and larger yields during July and August than would normally be expected.

Difference plan No. 2 has an advantage over difference plan No. 1 in reporting period yields. A sample taken from a cage-protected area represents, not only the herbage produced by new growth during the period since the previous samples were taken, but also the herbage which was present

TABLE 3

Comparison of "direct harvest" and "difference" plans of determining yields of bromegrass pastures under usual grazing conditions

Pounds of dry matter per acre

Date of sampling	Kind of sample			Yield for period	
	Direct harvest	Protected area	Open pasture	Difference plan	
				No. 1	No. 2
Field 1					
April 21	340	.....	340*	.....	.....
May 22	1782	1944	1150	794	1604
June 23	891	3013	1976	1037	1863
July 22	518	2624	956	1668	648
August 28	648	1604	535	1069	648
September 18	146	745	259†	486	210
Totals	4325	.....	.....	5054	4973
Field 2					
April 21	340	.....	340*	.....	.....
May 22	1992	2398	1863	535	2058
June 23	405	3143	1993	1150	1280
July 22	389	2252	1766	486	259
August 28	421	2090	632	1458	324
September 18	81	713	405†	308	81
Totals	3628	.....	.....	3937	4002

* Omitted in "difference plan" No. 1.
† Omitted in "difference plan" No. 2.

when the cage was put in place. Hence, the production of herbage for the period is best represented by subtracting the amount of herbage on open pasture on the previous sampling date from the protected sample of the present date. Thus in table 3, field 1, the protected area sample for May 22 of 1,944 pounds, minus the open pasture figure of 340 pounds on April 21 (difference 1,604 pounds), gives a better picture of the yield for the period than the figure of 794 pounds, which is obtained by subtracting the May 22 open pasture sample (1,150 pounds) from the protected area May 22 sample of 1,944 pounds.

Some investigators who used the difference plan of calculation term the

figures the amounts of forage consumed. Even if this term is used, it would appear, in the case of grass pastures such as bluegrass and bromegrass, that heavy consumption should occur in spring and early summer and large consumption during July and August would be unlikely; yet difference plan No. 1 indicates a larger total consumption during July and August than during May and June (table 3). Following this line of reasoning and keeping in mind the yields shown by the direct harvest plan, it would appear that difference plan No. 2 is a better measure of consumption than difference plan No. 1.

TABLE 4

Comparison of "direct harvest" and "difference" plans of determining yields of bromegrass pastures under usual-grazing and under delayed-grazing conditions

Pounds of dry matter per acre

Date of sampling	Kind of sample			Yield for period	
	Direct harvest	Protected area	Open pasture	Difference plan	
				No. 1	No. 2
Field 1					
April 29	1102	.....	1102*	.....	.....
May 26	1827	3320	1846	1474	2218
June 17	454	2058	567	1491	212
July 16	2446	1928	1134	794	1361
August 19	551	2495	697	1798	1361
September 15	1436	2661	1242†	1419	1964
Totals	7816	.....	.....	6976	7116
Field 2					
April 29	697	.....	697*	.....	.....
May 26	1474	3570	3570	0	2873
June 17	276	4989	4989	0	1419
July 16	1976	2074	1750	324	−2915
August 19	502	2689	729	1960	939
September 15	550	1763	826†	937	1034
Totals	5475	.....	.....	3221	3350

* Omitted in "difference plan" No. 1.
† Omitted in "difference plan" No. 2.

Difficulties in the application of the difference plans arise in connection with a rotation pasture system in which the grazing of one or more fields must necessarily be delayed beyond the usual sampling dates. An illustration of the effect of delayed pasturing on yield calculations is shown in table 4. The data are for the 1941 season. Field 1 was grazed prior to the taking of samples on May 26, while field 2 was not grazed until after the June 17 samples had been taken. The yields of field 1 calculated by each of the three methods agree reasonably well; but in the case of field 2, yields computed by the difference plans are much smaller than those obtained by

the direct harvest procedure. Further, in using difference plan No. 1, zero yields are shown up to July 16. Obviously, this is not a true representation of conditions. The direct harvest plan of sampling, therefore, is advantageous in determining the production of pasture herbage period by period throughout the growing season, but is not necessarily indicative of consumption. However, if the rate of grazing were such that nearly all of the herbage were regularly removed, then this plan would also indicate the amount of herbage eaten. On the other hand, the difference plans are less useful in determining actual yields period by period, and this is especially applicable in case of delayed pasturing; but they are valuable in computing the amounts of pasture forage consumed. The figures in table 4 for field 2, which are listed as yields for the period by the difference plans, evidently represent amounts consumed rather than yields. In nearly every instance in the pasture investigations conducted by the writer, delayed grazing and the taking of two or more consecutive monthly samples before the beginning of grazing resulted in smaller yield determinations by the difference plans than by the direct harvest plan.

Difference plan No. 3, which is the same as difference plan No. 2 except that residual herbage yields of the last sampling date are added, seems to have little or no advantage over the other difference plans. Usually, the amount of residual herbage on well-grazed grass pastures is small. If difference plan No. 3 were used in computing the yields of pastures given in table 3, the yield of field 1 would be 259 pounds more than calculated by plan No. 2, and the yield of field 2 would be 405 pounds more than obtained by plan No. 2. On the other hand, in 1941 there were unusually large amounts of residual forage on September 15 (table 4), and the addition of these figures would be a factor of no little importance. The statistical studies of the pasture yields presented in this paper show no advantage for the plan which includes the residual herbage of bluegrass pastures.

The results of the grazing trials on fields 5, 6a, and 6b are shown in table 5. Since fields 6a and 6b were pastured by one group of cattle and, beginning with 1939, were pastured as one field, they will here be considered as one unit. The data in the last four columns of the table give a measure of the productivity of the fields in terms of livestock values. Figures for the number of pasture days per acre were obtained by multiplying the number of days on pasture by the number of heifers and dividing by the area of the pasture in acres. These calculations are of only nominal value since they give little indication of the amount of feed obtained from pasture. The liveweight gain per head and per acre is a good measure of pasture yield. An additional measure, that of liveweight maintained per acre, is essential. Little or no liveweight gain may be made by mature animals, or when the pasture is heavily stocked with either young or mature cattle, and yet the pasture may provide large amounts of feed which serves as a maintenance

TABLE 5

Productivity of bluegrass pastures as measured by liveweight gains and maintenance of yearling dairy heifers

Field	Year	Grazing system	Pasture area	Number of heifers pastured	Number of days on pasture	Pasture days per acre	Liveweight gained		Liveweight maintained per acre
							Per head	Per acre	
			acres				*lbs.*	*lbs.*	*tons*
5	1937	Continuous	4.5	5	117	130	124	137	65.1
6a, 6b	1937	Alternated	4.5	5	117	130	133	148	64.2
5	1938	Continuous	4.5	5	167	186	197	219	72.0
6a, 6b	1938	Alternated	4.5	5	167	186	171	190	70.4
5	1939	Continuous	4.5	5.5	134	164	67	82	62.4
6a, 6b	1939	Alternated	4.5	5.2	134	153	102	118	58.9
5	1940	Continuous	4.5	7	90	140	51	79	41.5
6a, 6b	1940	Continuous	4.5	7	90	140	69	107	44.7
5	1941	Continuous	4.5	7	170	264	108	168	78.1
6a, 6b	1941	Continuous	4.5	7	170	264	122	190	74.8
5	1942	Continuous	4.5	7.15	150	238	72	114	73.7
6a, 6b	1942	Continuous	4.5	7.15	150	238	97	154	77.8

ration. In these trials the amount of liveweight maintained per acre was found by multiplying the average weight (average of three consecutive daily weights taken at four-week intervals) by the number of days on pasture and dividing by the number of acres.

It is evident from table 5 that there were striking seasonal differences in the number of pasture days per acre. Bluegrass pastures in this area are adversely affected by low rainfall during July and August. The seasons of 1937 and 1940 were characterized by low rainfall during these months, and in 1939 the rainfall was unusually low during July (table 6). Well-distributed rainfall through the pasture season gave a large number of pasture days per acre. The amount of liveweight gained tended to correspond with the number of pasture days per acre, but the relationship was not a close one. The data in the last two columns of table 5 show a well-defined relationship between rainfall and yield, the seasons of 1937, 1939, and 1940 (character-

TABLE 6

Rainfall during the grazing seasons

Inches

	1937	1938	1939	1940	1941	1942
April	5.40	3.42	5.39	3.96	4.21	3.32
May	2.59	4.97	1.19	4.53	3.94	3.57
June	5.43	5.67	6.17	5.04	6.19	3.92
July	2.43	6.45	1.73	0.95	3.27	4.94
August	0.80	4.28	6.38	2.80	3.64	2.58
September	5.34	0.88	0.32	0.48	4.91	3.86
October	3.92	2.50	2.54	1.93	9.01	2.36
Total for 7 months	25.91	28.17	23.72	19.69	35.17	24.55
Total for year	37.65	42.77	38.05	30.60	42.87	42.38

ized by low rainfall) showing lower yields than those for the other three years; further, the yields for the two pasture units, field 5 and field 6a–6b, agree well except in 1942. Such a finding is to be expected since these fields were alike in soil type, in kind of forage, and also received the same management.

The yields of total digestible nutrients per acre were obtained by applying to the gains in liveweight per acre the factor of 3.53 pounds of total digestible nutrients per pound of gain, as recommended in the report of three societies (3), and then adding to this value the amount of total digestible nutrients used for maintenance. The factor for maintenance was calculated from the maintenance requirements of 750-pound heifers and was estimated to be 7.76 pounds of total digestible nutrients daily per one thousand pounds liveweight.

TABLE 7

Amounts of dry matter as determined by different sampling procedures needed to produce one pound of total digestible nutrients

Bluegrass fields 6a and 6b

Year	Yield of total digestible nutrients	Pounds of dry matter per one pound of total digestible nutrients			
		Direct harvest plan	Difference plan No. 1	Difference plan No. 2	Difference plan No. 3
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*
1937	1519	1.95	2.62	2.17	2.29
1938	1763	2.26	3.02	3.00	3.36
1939	1331	2.26	1.99	1.92	2.23
1940	1071	2.67	2.22	2.27	2.61
1941	1832	2.06	1.82	1.74	1.97
1942	1751	2.51	2.36	2.22	2.11
Coefficient of variation		11.79	18.63	19.47	20.76

The question now arises, do the cattle data uphold the sampling data yields and, if so, which sampling plan gives best agreement with the grazing figures. Table 7, based on tables 1 and 5, helps in answering this question. Theoretically, the same number of pounds of dry matter in bluegrass pasture herbage of a given composition is needed to yield one unit of feeding value, regardless of the season. The data show less variability in this value for the direct harvest plan than for any of the difference procedures. This offers further support to the contention that the direct harvest plan has greater reliability than the other plans of sampling.

SUMMARY AND CONCLUSIONS

The sampling method of determining pasture yields is a simple and valuable tool in pasture research. Satisfactory yield determinations of bluegrass, bromegrass, and presumably other grass pastures which respond well with renewed growth after close cutting, can be made by this method.

The direct harvest plan of sampling is characterized by smaller standard errors and lower coefficients of variability than the difference plans. Tests of the variance of the data obtained in this investigation by four plans of sampling procedure show significant *F* values, for the direct harvest plan in a number of instances where such a finding would be expected, but no such values for the other plans. The direct harvest plan is advantageous in showing period yields and in computing yields where grazing is delayed because of a rotation plan of pasturing, or for other reasons. These advantages, together with its simplicity, make it highly suitable as the one plan of sampling where only yield determinations of grass pastures are desired.

The difference plans provide a valuable check on the direct harvest plan. They are much more satisfactory than the direct harvest plan in determining yields of crops such as soybeans and sweet clover, which may either be killed or greatly retarded in growth by frequent close cutting, and are also valuable in computing period-by-period amounts of herbage consumed in grazing. Statistical interpretations of the data show the difference plans to be somewhat less reliable than the direct harvest plan in determining yields of grass pastures.

Difference plan No. 2, in which open pasture yields of the previous sampling date are substracted from the protected area samples, is proposed as an improved plan of calculating yields over difference plan No. 1, in which open pasture yields are subtracted from the protected area yields of the same date.

Grazing trials with yearling dairy heifers furnished data for a comparison of bluegrass pasture yields, as determined by animals, with those obtained in the various sampling plans. The amount of liveweight maintained per acre, one of the valuable measurements of pasture yield, and the amount of animal weight gained per acre, served as a basis for the calculation of pasture yields in terms of total digestible nutrients. The total digestible nutrient values were more closely related to the yields of dry matter found by the direct harvest plan of sampling than to yields determined by the difference plans. The direct harvest plan of sampling, therefore, appears to be the most satisfactory one of the four plans of sampling for determining the yields of bluegrass pastures.

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THE MANUFACTURE OF CHEDDAR CHEESE FROM PASTEURIZED MILK

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Although pasteurization has been adopted almost universally in this country for market milk, the process has been used to only a limited extent in cheesemaking even though its advantages have been established by experimental work. As long ago as 1912, Sammis and Bruhn (4), in summarizing the results of work done at the University of Wisconsin in cooperation with the United States Department of Agriculture, stated that with pasteurized milk they obtained improvement in quality and more uniformity in the cheese, that the yield of cheese was increased, that there was less need for cold storage, and that the making process could be systematized to such an extent that it would be conducted on a fixed time schedule. More recently Marquardt (1) reported that pasteurization produced a slight but distinct improvement in the quality of experimental cheese. Price (3) confirmed the earlier results of Sammis and Bruhn, and added the significant observation that, while pasteurization is more effective when the qualtiy of the milk is inferior, the quality of cheese made from pasteurized milk varies with the quality of the raw milk. Phillips (2) also demonstrated that pasteurization makes the cheese more uniform and results in greater improvement when the raw milk is of poor quality or tends to be gassy. Stevenson (5) reported that pasteurization has been adopted generally by the cheese industry of New Zealand and it "has been an unqualified success."

In spite of the definitely favorable results mentioned above, there is still a general opinion among cheesemakers that the quality of Cheddar cheese would not be improved sufficiently by pasteurization to make the use of the process worth while. When this feeling becomes articulate, the objections appear to be based on two premises: (1) that cheese made from pasteurized milk does not develop a satisfactory Cheddar flavor; and (2) that pasteurization would be employed to make use of low-grade milk.

The data presented in this paper are the result of the Bureau's experimental work in the laboratory and some of the earlier introductory work in commercial plants. The work was begun in a preliminary way in several southern factories in 1927, and in Washington and Oregon in 1935, and has been conducted intensively both in the laboratory and in commercial plants

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since that time. The results show that the use of pasteurization in the making of Cheddar cheese is distinctly beneficial. We believe, therefore, that they refute the objections to the use of the process. Furthermore, they show that certain important factors which insure high quality and uniformity in cheese made from pasteurized milk have been overlooked.

EXPERIMENTAL RESULTS

Laboratory experiments. The milk used for making the experimental cheese under laboratory conditions was produced by the Bureau's herd at Beltsville, Md., and was of better quality than that received at the average factory. The methylene-blue reduction time of the milk when received was regularly more than 5 hours and usually more than 6 hours. For each experiment an 800-pound lot of milk was mixed in a receiving, weighing tank and divided into two equal portions. One half was pasteurized, and cooled, and the other half was not pasteurized (raw milk). In the earlier experiments, the test portion was heated to 144° F., held for 30 minutes, and cooled; in later work, it was pasteurized by the continuous method at approximately 162° F. for about 12 to 15 seconds. Except for the pasteurization of the milk used in one vat, exactly the same method was used for making the cheese in both vats, including the percentage of starter, the period and temperature of ripening the milk, the cheesemaking process, and the curing of the cheese. The cheese made in the earlier experiments was cured in cans, and that made in later work was put up in daisies. The cheese was cured at 50° F. and it was graded when it was 1 year old.

Partial manufacturing records and the scores of a representative series of experimental cheese are presented in table 1. The moisture content of the uncured cheese varied between 35.15 and 38.66 per cent; the average was 36.76 per cent. As shown by the scores in table 1, the cheese made from pasteurized milk was better in 19 out of 21 instances. All but one of the lots made from pasteurized milk scored 92.5 to 93.5, and 15 out of 21 lots (71 per cent) scored 93 or higher. Only five of the lots made from raw milk scored 92.5 or higher, and only two (10 per cent) scored 93. Four of the lots from raw milk scored from 91 to 89, while none of the lots from pasteurized milk scored lower than 92. The cheese made from pasteurized milk was uniformly good, and that made from raw milk definitely lacked uniformity. However, there was very little difference between the majority of the lots made from pasteurized milk and the few good lots made from raw milk, and it was the opinion of the judges that the average consumer would not be able to distinguish between them.

There were definitely off flavors in the three lots of raw milk cheese that scored 90 or lower. When off flavors occur in cheese made from raw milk that has a methylene-blue reduction time as long as 6 hours, it seems reasonable to expect a much higher proportion of off-flavored cheese in the average factory when the methylene-blue reduction time is less than 3 hours.

TABLE 1

Acidities, moisture contents, and scores of cheese made from raw and from pasteurized milk

Vat No.	Treatment of milk	Proportion of starter added	pH value		Moisture in green cheese	Score (1 yr. at 50° F.)
			At milling	At 24 hours		
		%			%	*Points*
207392	Raw	0.50	5.89	5.55	38.66	89.0
207391	Past.	0.75	5.35	5.24	38.03	92.5
208392	Raw	0.75	5.41	5.28	37.11	92.0
208391	Past.	0.75	5.34	5.28	38.18	93.0
209392	Raw	0.75	5.56	5.30	36.71	91.0
209391	Past.	0.75	5.46	5.13	37.66	93.0
210392	Raw	0.75	5.50	5.24	36.51	92.0
210391	Past.	0.75	5.37	5.13	37.24	92.5
214392	Raw	0.75	5.54	5.26	38.16	92.5
214391	Past.	0.75	5.39	5.28	37.45	93.0
215392	Raw	0.75	5.53	5.17	36.36	92.0
215391	Past.	0.75	5.43	5.20	37.10	93.0
216392	Raw	0.75	5.55	5.45	37.66	90.0
216391	Past.	0.75	5.37	5.28	36.62	93.0
221392	Raw	0.75	5.56	5.26	36.89	92.0
221391	Past.	0.75	5.43	5.14	36.63	93.0
223392	Raw	0.75	5.68	5.41	36.54	92.0
223391	Past.	0.75	5.37	5.34	35.69	93.0
224392	Raw	0.75	5.58	5.34	37.18	92.0
224391	Past.	0.75	5.33	5.21	37.45	93.5
104092	Raw	0.5	5.50	5.27	37.18	92.5
104091	Past.	0.5	5.54	5.40	37.09	93.0
104232	Raw	0.5	5.39	5.31	37.61	92.0
104231	Past.	0.5	5.45	5.31	36.66	93.0
107291	Raw	0.5	5.50	5.41	35.09	89.0
107292	Past.	0.5	5.56	5.48	35.15	92.0
109091	Raw	0.5	5.44	5.23	33.60	92.0
109092	Past.	0.5	5.44	5.30	35.46	93.0
109161	Raw	0.5	5.36	5.20	37.04	93.0
109162	Past.	0.5	5.35	5.27	36.04	92.5
109231	Raw	0.5	5.42	5.32	35.61	93.0
109232	Past.	0.5	5.49	5.29	37.26	92.5
110141	Raw	0.75	5.24	5.20	37.27	92.0
110142	Past.	0.75	5.38	5.29	37.70	93.0
110211	Raw	0.75	5.42	5.30	36.96	92.0
110212	Past.	0.75	5.42	5.30	37.05	93.0
110231	Raw	0.75	5.38	5.29	36.66	92.5
110232	Past.	0.75	5.35	5.20	35.89	93.0
110281	Raw	0.75	5.45	5.32	37.00	92.0
110282	Past.	0.75	5.48	5.24	35.89	93.0
111051	Raw	0.75	5.48	5.18	36.74	92.0
111052	Past.	0.75	5.43	5.27	35.37	92.5
(Average)	Raw	.....	5.49	5.30	36.79	91.74
	Past.	.....	5.42	5.27	36.74	92.86

In these experiments some of the canned cheese was cured for 33 months and then examined and graded. At this time, the lots made from pasteur-

ized milk were still of excellent quality and had a fine, well-developed, pleasing flavor. The cheese made from raw milk that had scored 92 or higher when 1 year old had developed a slightly sharper but not as pleasing flavor, and did not "clean up" as well, as the pasteurized milk cheese. The raw milk cheese was criticized also by the judges as having an acid and, in some instances, even a bitter flavor.

It should be noted that, although the milk was presumably of good quality as indicated by the methylene-blue test, some of the raw milk cheese developed defects, indicating that it is difficult to grade out all milk that contains bacteria that have an injurious effect on the ultimate quality of the cheese.

Experiments with inoculated and ripened milk. The following series of experiments was designed to determine the effect of pasteurizing milk of poor bacteriological quality. For each experiment, a 1600-pound lot of milk was ultimately divided into four equal parts as follows: first, it was divided by accurate weight into two equal halves, and one half was divided again into two 400-pound lots. One of these portions was pasteurized at 162° F. by the continuous method, as described above, and the other was not pasteurized; both were made into cheese by methods which were identical. The other half of the original lot was inoculated with 500 ml. (in a few instances 1000 ml.) of an active culture of either *Aerobacter aerogenes* or *Streptococcus lactis* grown in milk, or in some instances with a mixture of these two organisms. The milk was then warmed to and allowed to ripen at 73° F., or in a few instances at a slightly higher temperature, for from 3 to 5 hours, after which it was cooled to 40° F. and held overnight at that temperature. On the following morning this lot was divided; one half was pasteurized as described above and the other half was made up raw.

Thus four lots of cheese were made from each lot of milk of originally good quality—one vat from the original milk after it was pasteurized, one from milk of the same quality but not pasteurized, one from this milk after the growth of detrimental bacteria and subsequent pasteurization, and one from the inoculated and ripened milk without pasteurization. Efforts were made with the inoculated and ripened milk to gauge the amount of inoculum and the incubation time and temperature to produce conditions similar to those that might occur often when contaminated and ripened milk is received in factories, and also to make the effects on the milk as nearly uniform as possible. The quality of the milk in the inoculated and ripened portions was impaired in all instances, and in some lots the milk was noticeably off-flavored and gassy.

A partial record of the cheesemaking data and the scores of the cheese at 6 months are shown in table 2. Usually, but not invariably, pasteurization improved the quality of the cheese made from the uninoculated lots of milk.

In nearly every instance, the cheese made from the inoculated and

ripened milk was considerably inferior to that made from the corresponding milk of good quality. Although pasteurization improved the inoculated and

TABLE 2

Acidities of curd, and moisture contents and scores of cheese made from raw and pasteurized samples of normal (good quality) and inoculated, ripened (poor quality) portions of a milk

Vat No.	Treatment of milk	pH of curd at milling	Moisture in green cheese	Score (6 months at 50° F.)
			%	*Points*
104092	Raw	5.50	37.18	92.5
104091	Pasteurized	5.54	37.09	92.0
104102	Raw*	5.03	39.74	87.0
104101	Pasteurized*	5.37	38.13	92.0
104232	Raw	5.39	37.61	92.5
104231	Pasteurized	5.45	36.66	92.0
104242	Raw*	5.18	40.14	85.0
104241	Pasteurized*	5.45	40.68	87.0
107291	Raw	5.52	35.09	89.0
107292	Pasteurized	5.56	35.15	92.0
107301	Raw*	5.45	36.35	85.0
107302	Pasteurized*	5.30	39.58	88.0
109161	Raw	5.36	37.04	93.0
109162	Pasteurized	5.35	36.24	92.5
109171	Raw*	5.17	34.90	92.0
109172	Pasteurized*	5.47	37.63	91.0
109231	Raw	5.42	35.61	93.0
109232	Pasteurized	5.49	37.26	92.5
109241	Raw*	5.23	35.20	91.0
109242	Pasteurized*	5.56	37.88	92.0
110141	Raw	5.24	37.27	92.0
110142	Pasteurized	5.38	37.70	93.0
110151	Raw*	5.18	35.53	91.0
110152	Pasteurized*	5.45	38.84	91.0
110161	Raw	5.31	36.11	91.5
110162	Pasteurized	5.17	36.05	88.0
110171	Raw*	5.11	35.24	88.0
110172	Pasteurized*	5.30	39.74	89.0
110211	Raw	5.42	36.96	92.0
110212	Pasteurized	5.42	37.05	93.0
110221	Raw*	5.15	34.86	91.0
110222	Pasteurized*	5.32	39.37	90.0
110231	Raw	5.38	36.66	92.5
110232	Pasteurized	5.35	35.89	93.0
110241	Raw*	5.16	34.75	90.0
110242	Pasteurized*	5.37	39.25	91.0
110281	Raw	5.45	37.00	92.0
110282	Pasteurized	5.48	35.89	93.0
110291	Raw*	5.19	36.35	90.0
110292	Pasteurized*	5.32	38.40	90.5

* Inoculated and ripened.

ripened milk, in some instances increasing the score of the cheese by several points, nearly all of the cheese made from milk of inferior quality was very poor even when the milk was pasteurized. The results indicate that pas-

teurization is only partially, but not by any means completely, effective in avoiding the defects caused by poor quality in the milk.

It will be noted in table 2 that, in general, the cheese made from inoculated and ripened milk had lower pH values (higher acidity) at milling than the cheese made from normal milk. In two instances (Nos. 104102 and 110171), the acidity at milling was abnormally high and the cheese was very inferior in quality. The one cheese from uninoculated and pasteurized milk that was not of good quality (No. 110162) was the only cheese of this type that scored less than 92, and it had a pH value of 5.17 at milling. When making cheese from pasteurized milk with a time interval of 4½ hours from setting to milling, such a high acidity is unusual and the cheese is generally of poor quality.

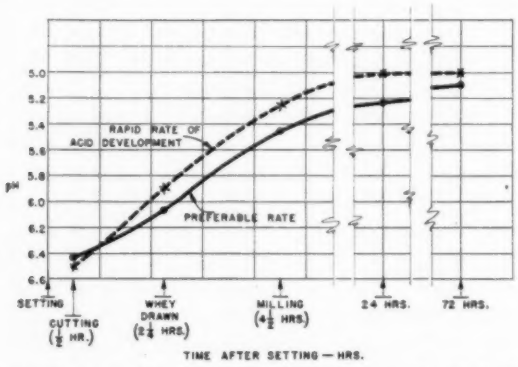

FIG. 1. Illustrating a rapid rate and a preferable rate of acid development during the making process.

Development of acidity. The development of acidity in Cheddar cheese follows a rather definite pattern and, while dependent to some extent on the effects of buffers occurring in the cheese and on factors which may retard the fermentation, eventually it usually tends to reach a point determined by the exhaustion of the milk sugar (lactose) from which the acid is formed. The maximum acidity reached in normal cheese is usually approximately pH 4.95 to 5.05. However, the time required to reach this point, *i.e.*, the rate of acid formation, is very important in making good cheese, and while it may vary quite widely, it can be controlled advantageously within proper limits by the cheesemaker. The usual course of the formation of acid is illustrated by two typical curves shown in figure 1. The rate of development of acidity represented by the broken line is relatively rapid, and a pH value of 5.0 is reached within 24 hours from the beginning of the making process. At this stage the milk sugar is usually all or very nearly all fermented, and any further change in the reaction during curing is usually limited to a slight decrease of acidity, *i.e.*, an increase in pH value. The

rate of increase of acidity represented by the solid line in figure 1 is definitely slower and is more characteristic of the acid development in cheese made from pasteurized milk of reasonably good quality and made under properly controlled conditions. In this instance the final point in acid formation is not reached until some time after the cheese is 1 day old.

In the course of acid formation, the gas-forming bacteria of the type used in the inoculation-and-ripening experiments recorded in table 2 have been practically inactivated before the acidity reaches pH 5.2. They usually do not grow in the cheese in the curing room, and it is apparent that their detrimental effect on the quality of the cheese is produced largely by their growth and activity in the milk before and during the making process.

The relation of the rate of acid development to the quality of cheese is shown in figure 2, in a tabulation of data on 100 cheeses made in the labora-

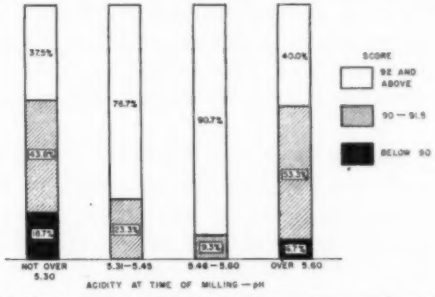

FIG. 2. The distribution of the grades of cheese from curd of different acidities at time of milling.

tory from milk of good quality and 45 cheeses made under the supervision of one of us in a commercial plant. Nearly all of these cheeses were made from pasteurized milk.

These data were divided into four groups on the basis of the pH at milling, which is fairly indicative of the bacterial activity and of the rate of acid formation. There were 16 cheeses in the group having a pH of not more than 5.30 at milling, 60 having a pH between 5.31 and 5.45, 54 having a pH between 5.46 and 5.60, and 15 having a pH higher than 5.60. The data in each of these four groups were subdivided into three grades on the basis of the final scores of the cheese. In the group having the lowest pH (highest acidity) at milling, the proportion of undergrade cheese was relatively high. In the group having a pH of 5.31 to 5.45 at milling, there were no undergrades, and more than three-fourths of the cheese scored 92 or higher. In the group having a pH of 5.46 to 5.60, the proportion of good cheese was even higher. In the group in which the fermentation was so slow that a pH of 5.60 (low acidity) was not reached at milling, the proportion of undergrade and medium grade cheese increased.

There is apparently a fairly wide range of acidity within which the fermentation should be controlled, and some good cheese may be produced occasionally with pH values at milling both above and below the limits of the second and third groups shown in figure 2 (pH higher than 5.6 or lower than 5.3). However, to secure uniformly good quality, an effort should be made to control the pH within a range of approximately 5.4 to 5.5 at milling when the time schedule for pasteurized milk cheese shown in figure 3 is followed.

It should be remembered that the pH determinations are made on samples of the curd and that the titratable acidity of the whey at milling does not necessarily give an accurate indication of the reaction of the curd. However, tabulations of the records of 104 vats show that, while the relation between pH value and titratable acidity is subject to rather wide variations, a titratable acidity of the whey of 0.35 to 0.50 per cent, calculated as lactic acid, at milling corresponds in most instances with a pH value that is within the indicated limits of 5.6 to 5.3. This conclusion has been found applicable for use with the time schedule for pasteurized milk cheese, which is shown in figure 3.

Preliminary results in factories. Work with commercial factories has amply demonstrated that the principles developed in the laboratory are applicable under commercial conditions. In this work, however, various circumstances combined to prevent the making of direct or experimental comparisons by dividing the milk in one factory, or even to compare cheese in a single factory from raw milk with cheese made in the same factory from pasteurized milk.

A summary of results obtained in each of two typical, small factories is shown in table 3. A laboratory was installed at each of these factories, and complete manufacturing records were obtained throughout the major part of the season. In factory W the cheese was made from raw milk, and no attempt was made to change the methods used habitually by the cheesemaker. In factory B a continuous pasteurizer was installed, and all of the cheese was made from pasteurized milk. The milk was graded, and an attempt was made to control the quality on the basis of the methylene-blue test. The average methylene-blue reduction time of the milk was 3.45 hours, and the quality was comparatively good. A good starter culture was maintained in the laboratory and used in the cheese, a regular time schedule was followed in the making process, and the acidity was controlled as closely as possible throughout the process. The records show that the making process was quite uniform from day to day, and the averages given in table 3 may be considered representative of the routine conditions.

The milk received at factory W was of inferior quality, and the methylene-blue reduction time of the vat milk was usually less than 2 hours. Even with milk of this grade the effect of differences in quality of the milk is

TABLE 3

Acidity, moisture content, and score of cheddar cheese made from raw milk by the usual method and from pasteurized milk by a controlled method of manufacture (averages of data for 154 lots)

Factory	Number of vats	Methylene-blue reduction time of raw milk	Treatment of milk	pH value		Moisture in green cheese	Score
				At milling	At 24 hours		
		Hours				%	*Points*
W	89	1.51	Raw	5.47	5.14	38.03	90.23*
B	65	3.45	Pasteurized	5.44	5.31	37.46	92.15†

* 3 months' storage at 34° F.
† 3 to 5 months' storage at 34° F.

apparent in the quality of the cheese. The data in table 4 show that a definitely larger proportion of undergrade cheese occurred when the reduction time was less than 1 hour than when it was between 1 and 2 hours. A similar difference is indicated between the cheese from milk having a reduction time between 1 and 2 hours and that from milk having a reduction time greater than 2 hours. The importance of this factor in the production of cheese of high quality cannot be overemphasized.

In factory W the rate of development of acidity in the cheese was so rapid that in many instances the ultimate pH value was reached and the sugar was practically exhausted when the cheese was removed from the press. This is indicated by the low average pH at 24 hours. However, the pH at milling cannot be compared with that at factory B because of the difference in time. In factory W the time from setting to milling was seldom as long as 3½ hours and was frequently less than 3 hours. In factory B the time schedule included a period of 4½ hours from setting to milling, and it was seldom necessary to deviate from this fixed period. The control of acidity was maintained by carrying a uniformly active starter and regulating the amount used in such a manner as to bring the pH at milling to the desired point. Nothwithstanding the ripeness of the milk received at factory W, from 1 to 1.5 per cent of starter was added while, with pasteurized milk at factory B, the amount of starter was usually limited to 0.5 per

TABLE 4

The percentage distribution of the grades of cheese made from raw milk of varying quality as indicated by the methylene-blue reduction time

Methylene-blue reduction time	Number of vats	Proportion of cheese in each grade*		
		Score 92 or higher	Score 90 to 91.5	Score 89.5 or lower
		%	%	%
Less than 1 hr.	16	25	6	69
1 to 2 hrs.	42	14	48	38
2 hrs. or more	31	29	61	10

* Cheese cured for 3 months at 34° F.

cent. As a consequence of the retardation of the fermentation, the average pH of the cheese when it was removed from the press was 5.31, and very few of the individual pH values were as low as 5.20.

The relation of these two methods to the quality of the cheese is reflected in the averages of the scores shown in table 3. While it is not strictly conclusive to make a direct comparison between cheese made at two different factories, our rather extensive experience at other similar plants seems to justify the opinion that the adoption of the controlled, pasteurized-milk method used in factory B will produce similar improvement in quality in any factory operating under similar conditions.

Time schedule for cheesemaking operations. Excepting the quality of the milk, the control of acidity probably has more influence on the quality of Cheddar cheese than any other factor in the making process. The use of milk that is overripe, high in acidity, and gassy, the use of starters that vary too much in activity, and the addition of too much starter are the principal causes of excessive acidity in the cheese. It is essential that the amount of acid at each stage of the making process be within a proper range, but it is also essential that the duration of time required to reach the desired acidity be controlled. To make cheese of uniformly high quality, the amount of starter and the ripening period should be adjusted so that, at the time of milling, or 4½ hours after setting, the whey draining from the curd will have a titratable acidity of approximately 0.5 per cent. We have found that a period of 2 hours and 15 minutes from setting to dipping, and the same period from dipping to milling—a total of 4½ hours from setting to milling—yields cheese of very satisfactory quality. The cheddaring time from dipping to milling may be increased to 3 hours and 15 minutes, in which case acidity as high as 0.6 to 0.7 per cent may be developed at milling. The longer cheddaring time usually results in producing cheese that has a more pronounced flavor and is faster curing and safer to hold in storage. The only disadvantage of the longer method is the extra time involved.

Figure 3 shows the time schedule in graphic form, which was prepared for the convenience of the cheesemaker. Strict adherence to the schedule for each operation not only simplifies the work but is extremely important for the production of a good quality of cheese in every vat day after day. To obtain the best results from using the schedule, however, a definite milk-quality improvement program should be maintained, the milk must be properly pasteurized, a uniform and not too large proportion of starter of uniformly high activity should be used, and the duration of the ripening period in the vat should be uniform.

Curing temperatures. Experiments on the effects of different curing temperatures for curing cheese of varying quality have been described in an earlier publication (6). A comparison of the quality of cheese manufactured at factories W and B and cured at 34° F. has been given in table 3.

Duplicate cheese made at these factories were also cured at higher temperatures. At factory B, where the milk was of reasonably good quality accord-

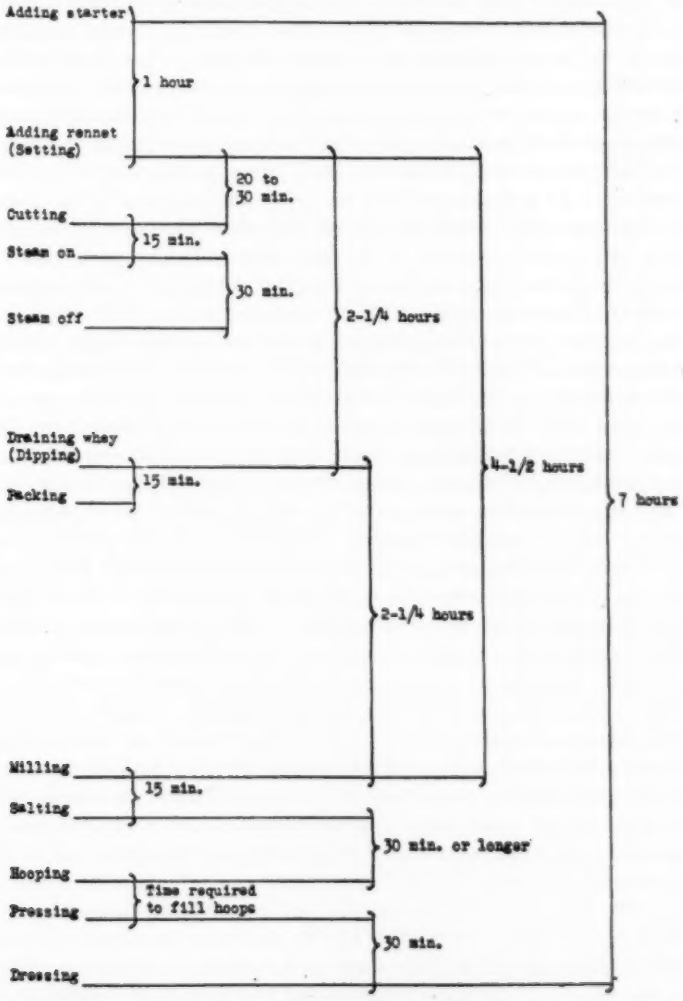

FIG. 3. Time schedule for making American Cheddar cheese from pasteurized milk (4¼-hour method).

ing to the methylene-blue test and was pasteurized, a comparatively large proportion of the cheese was of excellent quality, in spite of a relatively high curing temperature of 55° to 60° F. At factory W, where the milk was of

poorer quality as indicated by the methylene-blue test and was not pasteurized, practically all of the cheese was definitely undergrade when cured at 60° F. Apparently the higher curing temperatures accentuate defects inherent in cheese from low-grade milk. The value of a curing temperature as low as 34° is evidently in its retarding action on the development of undesirable flavors and body and texture defects, and for this reason a relatively low temperature is especially suitable for holding cheese that is not properly made or that is made from the lower grades of milk.

The curing temperature has a marked effect on the factors responsible for ripening. At a temperature as low as 34° F., enzymes (those inherent in the milk, those added with the rennet, and those produced by bacteria in the milk and starter) continue to produce chemical changes, but only at a relatively slow rate. The action of bacteria is largely, if not completely, inhibited at this temperature. Only a limited number of bacterial species are able to grow under the conditions of salt concentration, pH value, and strict anaerobiosis existing in Cheddar cheese; and at this low temperature both the bacterial activity and the number of varieties that can survive are further restricted. While temperatures as low as 34° F. retard the factors producing unfavorable effects in cheese, they also retard the rate of ripening and the production of flavors, including the characteristic Cheddar flavor. The enzymatic and other chemical action that occurs at a low temperature results in certain chemical changes, particularly in the proteins, which slowly alter the physical properties of the curd and change the flavor to some extent, but it is evident that the pleasing flavor characteristic of the best cheese is the result of the action of bacteria. This action cannot be obtained in sufficient degree at a temperature as low as 34° F. and in order to secure characteristic ripening at a normal rate the cheese must be cured at a temperature at which the essential bacteria can function. At 50° F., slow but continuous bacterial activity occurs, and at this temperature cheese properly made from pasteurized milk develops a characteristic Cheddar flavor which cannot be distinguished from that of cheese made from raw milk of high quality and ripened under equally favorable conditions. The ripening may be somewhat slower than that of raw milk cheese, but the cheese is practically always free of the sharp, biting flavors that occur frequently in raw milk cheese. The acid and bitter flavors that are encountered frequently in raw milk cheese, even when it is held at 34° F., appear to be largely a result of an over-development of acidity during the making process—a chemical action, the effects of which are retarded but not entirely prevented by storage at a low temperature.

CONCLUSIONS

The observations recorded in this paper support the conclusion expressed by other investigators that the quality of the milk is one of the most important, if not the most important, of the factors determining the quality of

Cheddar cheese. A milk supply of inferior quality can be detected by careful grading of the milk at the intake, supplemented by use of the methylene-blue test; and the detrimental effect of inferior quality in the milk can be partly overcome by pasteurization, which destroys the lactic and gas-producing bacteria and thus permits the cheesemaker to control the fermentation in the vat. While pasteurization destroys the harmful bacteria, it does not remove entirely the effects which these bacteria produced in the milk prior to pasteurization, and in general the quality of cheese made from pasteurized milk by a controlled process is directly dependent on the bacteriological quality of the original milk.

The rate at which acidity develops during the making process has a definite effect on the quality of the cheese, and the beneficial effects of pasteurization may be entirely nullified by so accelerating the fermentation of the milk sugar that it is exhausted and the point of maximum acidity reached by the time the cheese is removed from the press.

The belief that, because pasteurization destroys the lactic acid-forming bacteria, it is necessary to use a larger amount of starter is probably responsible for much of the objection that has been raised against this process for cheesemaking. Our results show that the amount of starter should be limited to an extent that will insure a slow but gradual fermentation so that at milling—not less than 4½ hours after setting—the pH of the curd will be not below 5.30 and not much above 5.50, preferably between 5.40 and 5.50. When the cheese is removed from the press about 24 hours after setting, it should still contain an appreciable amount of milk sugar for continuance of the fermentation. This slow, gradual rate of fermentation with pasteurized milk of good quality will avoid the acid and bitter flavors that impair a large proportion of the Cheddar cheese as it is commonly made.

Cheese made from pasteurized milk of good quality with proper control of the acid development can be ripened safely at a temperature high enough to permit the continued activity of the essential bacteria and thus insure the development of the characteristic Cheddar flavor. This temperature may be as high as 50° F., and possibly even higher. A temperature as low as 34° F. should be used not for ripening cheese but for storing ripened cheese and for retarding further changes, particularly the development of undesirable flavors.

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FAT DEGRADATION IN CHEDDAR CHEESE MADE FROM PASTEURIZED MILK, WITHOUT AND WITH ADDED LIPASE[1,2]

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The factors influencing flavor development in cheddar cheese have been extensively investigated, with the early studies largely involving the relationship of protein degradation to flavor production. Recently, the Iowa Agricultural Experiment Station has been investigating the relationship of fat degradation to flavor development (2, 3).

As early as 1891, Van Slyke (6) stated that the chemical changes involved in the ripening of cheddar cheese were primarily a decomposition of the fats with the formation of free fatty acids. These changes were said to occur mainly after the earlier stages of ripening. Suzuki, Hastings and Hart (5) concluded from their studies that the fat was the main source of the higher fatty acids present in cheddar cheese. Enzymes or organisms contained in the cheese were thought to be capable of hydrolyzing glycerides. The authors stated that further experiments were necessary to show whether this action was due to lipases inherent in the milk or to living organisms.

Lane and Hammer (2) found that the fat acidities of cheese made from raw milk were slightly higher than those of cheese made from pasteurized milk when the cheese were fresh and also increased more during ripening. When extracted with ether and the ether evaporated, steam distillates from aged cheese yielded oily residues having an odor suggestive of higher volatile fatty acids. These investigators (3) also made cheese from raw homogenized cream mixed with skim milk (raw or pasteurized). The cheese commonly developed a rancid flavor early in the ripening, but the rancidity tended to disappear as ripening progressed, and eventually the cheese were not rancid and were more satisfactory in flavor than cheese made from pasteurized milk or from pasteurized homogenized cream mixed with pasteurized skim milk. In some cases the cheese were more satisfactory in flavor than cheese made from raw milk. Addition of pancreatin to pasteurized milk resulted in a rancid and bitter flavor in the cheese but addition of desiccated mammary tissue commonly had a desirable effect on the cheese flavor. The mammary tissue increased the fat acidities of the cheese and also the soluble nitrogen contents.

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METHODS

The milk used for cheese manufacture was mixed herd milk with a fat content of 3.8 to 4.0 per cent. It was pasteurized at 143° F. for 30 minutes in a spray-vat pasteurizer. Fifty gallons of milk was used for each trial. In all trials the method of manufacture followed was essentially that of Wilson (7). The cheese were ripened at 50° F.

The method used for determining the pH of the cheese was that described by Sanders (4) for the determination of pH of semi-plastic solids.

The cheese fat was obtained by subjecting a mixture of finely grated cheese and sand to relatively high pressures in a hydraulic press (2). The fat was filtered through paper and titrated according to the method suggested by Breazeale and Bird (1).

RESULTS

Fat degradation in control cheese from pasteurized milk. The fat acidities of 21 lots of cheese made from pasteurized milk are presented in table 1.

TABLE 1

Fat acidities of cheddar cheese made from pasteurized milk. No lipase added

Date of manufacture	Acid No. of fat (ml. N/20 KOH per 10 gm. fat)					
	3 days	1 month	2 months	3 months	6 months	9 months
12–18–42	1.46	1.88	2.09	2.10	2.85	3.46
12–22–42		1.63	1.69	1.74	2.75	3.52
12–26–42	1.50	1.53	2.03	2.22	3.20	3.92
12–29–42		1.52	1.60	1.91	3.40	4.11
1– 7–43	1.42	1.67	1.79	2.29	3.72	4.73
1–11–43		1.75	1.93	2.02	3.27	4.40
1–18–43	1.48	1.88	2.29	2.49	4.38	5.29
1–25–43		1.41	1.98	2.25	3.22	4.06
2– 1–43	1.51	1.59	1.90	2.20	3.29	4.37
2– 8–43		1.74	2.12	2.13	2.74	3.54
2–15–43	1.44	1.50	2.01	2.39	2.79	3.13
2–22–43		1.47	2.05	2.20	2.98	3.64
3– 1–43	1.50	1.61	1.88	2.34	3.57	5.62
3– 8–43		1.48	1.67	2.00	2.40	3.01
3–22–43	1.52	1.75	2.20	2.45	3.51	5.31
3–29–43		1.71	2.04	2.34	2.88	3.61
4– 5–43	1.45	2.32	2.45	2.64	3.12	3.95
4–12–43		2.04	2.36	2.59	3.02	3.61
4–19–43	1.41	1.82	2.21	2.53	2.98	3.65
4–26–43		1.83	2.06	2.24	2.51	2.91
5– 4–43	1.40	1.41	1.52	1.75	2.34	3.08
Average	1.46	1.69	1.99	2.23	3.09	3.95

Only slight variations were observed in the original acidities of the eleven lots of cheese on which determinations were made 3 days after manufacture; the values ranged from 1.40 to 1.52 and averaged 1.46. The fat acidities increased during ripening at a more or less regular rate. On the basis of

averages, they increased the first month by 0.23, the second month by 0.30 and the third month by 0.24; from the third to the sixth month they increased by 0.86 (equal to 0.287 per month) and from the sixth to the ninth month by 0.86 (equal to 0.287 per month). With some of the cheese the fat acidities increased more rapidly than with others. The increases were not correlated with the pH of the cheese, the acidity of the whey at milling or the moisture or fat content of the cheese.

In three trials rennet extract and rennet powder were compared from the standpoints of quality of cheese and fat degradation in it. No significant

TABLE 2

Fat acidities and degree of rancidity of cheddar cheese made from pasteurized milk. Lipase added in form of rennet paste

Date of manufacture	Per 1000 lbs. milk		Acid No. of fat (Ml. N/20 KOH per 10 gm. fat)		Flavor of cheese	
	Gm. rennet paste	Ml. rennet extract	3 months	6 months	3 months	6 months
1–25–43	13	85	2.40	3.89	Not rancid	Not rancid
1–11–43	13	85	3.14	5.82	Not rancid	Not rancid
3– 8–43	40	74	2.64	3.64	Not rancid	Not rancid
12–22–42	40	74	2.35	3.73	Not rancid	Not rancid
12–18–42	40	74	2.51	4.50	Not rancid	Not rancid
1–25–43	40	74	2.83	4.50	Not rancid	Not rancid
3– 1–43	40	74	3.40	4.76	Not rancid	Not rancid
1–18–43	40	74	3.81	6.55	V. sl. rancid	Not rancid
1–18–43	40	74	3.73	6.70	V. sl. rancid	Not rancid
1–11–43	40	74	3.51	6.96	Sl. rancid	Sl. rancid
12–26–42	50	70	3.26	5.21	Sl. rancid	Sl. rancid
12–29–42	50	70	3.52	6.08	Sl. rancid	Sl. rancid
12–26–42	50	70	3.90	6.23	Not rancid	Sl. rancid
12–29–42	50	70	4.03	7.23	Not rancid	Sl. rancid
12–18–42	80	58	3.29	3.85	Sl. rancid	Not rancid
3– 8–43	80	58	3.71	4.38	Sl. rancid	Sl. rancid
12–22–42	80	58	2.99	5.85	Rancid	Not rancid
3– 1–43	80	58	5.71	8.56	Rancid	Rancid
1– 7–43	225	0	8.10	15.25	V. rancid	V. rancid

difference in flavor was evident, and the fat acidities increased at approximately the same rate.

In an attempt to explain the cause of fat degradation in the cheese, purified butterfat was prepared from fresh, pasteurized sweet cream. The sweet cream was pasteurized at 145° F. for 30 minutes, cooled and churned. The resulting butter was held at 104° F. until the butterfat and serum had separated. The butterfat was then filtered through paper and portions held in erlenmeyer flasks at the cheese ripening temperature (50° F.). There was no significant increase in the fat acidity, even after holding for approximately 8 months; during this period the fat acidity increased from 1.20 to 1.25.

Fat degradation in cheese made with rennet paste. Table 2 shows the fat

acidities and degrees of rancidity of 19 lots of cheddar cheese made from pasteurized milk with various amounts of lipase added in the form of rennet paste. In the manufacture of the cheese, 225 grams of paste was considered equivalent to 3 ounces of rennet extract; and, as the amount of rennet paste was increased, the amount of rennet extract was decreased in proportion so that the coagulating power would remain the same.

The fat acidities of the two lots of cheese made with rennet paste added at the rate of 13 grams per 1,000 pounds of milk showed increases over the control cheese (table 1), the increase being considerably greater in one case than in the other. The cheese were not rancid at any time during the ripening and at 3 months, 6 months and 9 months were considered to be slightly better in flavor than the cheese made without added lipase. The small amount of rennet paste increased the cheese flavor and tended to mask the slightly sour flavor evident in the control cheese.

When rennet paste was added at the rate of 40 grams per 1,000 pounds of milk, the fat acidities did not increase in proportion to the increases obtained when 13 grams of the paste was added. There was considerable variation in the increases with the different trials and with two of the eight lots of cheese the fat acidities at 6 months were slightly lower than in one of the trials with 13 grams of paste. Each of the eight lots of cheese in the series showed some rancid flavor during the first 3 months, although at 3 months five of them were not rancid; at 6 months only one lot was slightly rancid and it had the highest fat acidity. At 6 months seven of the eight lots of cheese were considered to have a better flavor than the corresponding control cheese and one lot was considered equal in flavor to the control cheese.

Four lots of cheese were made with 50 grams of rennet paste per 1,000 pounds of milk. A slightly higher average fat acidity was obtained than with 40 grams of paste. However, with the 50 gram additions, all four lots of cheese were slightly rancid after 6 months. The slight rancidity was not considered definitely objectionable by some of the judges while it was by others.

Four lots of cheese were made with 80 grams of rennet paste per 1,000 pounds of milk. The fat acidities after 6 months showed a rather wide variation (3.85 to 8.56). At 3 months all of the lots showed some rancidity but at 6 months only two lots were rancid. At 6 months two lots in the series were considered to have a better flavor than the corresponding control cheese and two lots were considered inferior in flavor.

Three lots of cheese were made with rennet paste as the sole coagulating agent (225 grams per 1,000 pounds of milk) but the fat acidities were determined on only one of them. The fat acidity increased rather rapidly and a value of 15.25 was obtained at 6 months. All three lots of cheese in the series were very rancid throughout the entire ripening period (9 months).

The variations within a series could not be correlated with the pH of the cheese. Also, there was no correlation between the amount of rennet paste used and the increase in pH of the cheese on holding.

Fat degradation in cheese made with mulberry juice. Results of 12 trials in which mulberry juice was used as a source of lipase are presented in table 3. The mulberry juice was obtained from frozen berries by grinding and pressing and was usually prepared only a short time before it was to be used. It was noted that the lipolytic activity of mulberry juice decreased rapidly if a very acid juice was allowed to stand; neutralization of the acidity helped to preserve the activity. The mulberry juice was added in amounts ranging from 50 to 200 ml. per 1,000 pounds of milk and in each trial the normal amount of rennet extract was used.

TABLE 3

Fat acidities and degree of rancidity of cheddar cheese made from pasteurized milk. Lipase added in form of mulberry juice

Date of manufacture	Ml. mulberry juice per 1000 lbs. milk	Acid No. of fat (Ml. N/20 KOH per 10 gm. fat)		Flavor of cheese	
		3 months	6 months	3 months	6 months
2– 1–43	50 (Lot 108)	2.25	3.21	Not rancid	Not rancid
2– 8–43	50 (Lot 103)	3.69	5.72	Not rancid	Not rancid
3–22–43	65 (Lot 110)	9.12	15.77	Rancid	Rancid
3–29–43	80 (Lot 110)	8.12	13.20	Rancid	Rancid
2–22–43	150 (Lot 110)	13.75	22.54	Rancid	Rancid
2–22–43	150 (Lot 110)	16.49	26.66	Rancid	Very rancid
3–29–43	160 (Lot 110)	9.62	13.71	Rancid	Very rancid
2– 8–43	175 (Lot 103)	6.07	10.07	Sl. rancid	Sl. rancid
2– 1–43	200 (Lot 108)	3.23	5.36	Sl. rancid	Not rancid
2–15–43	200 (Lot 110)	12.72	21.72	Sl. rancid	Sl. rancid
2–15–43	200 (Lot 110)	14.87	24.87	Sl. rancid	Rancid
3–22–43	200 (Lot 110)	15.33	25.26	R. ncid	Rancid

With the smallest amount of juice (50 ml.), the fat acidity in one trial was no greater than that of the control cheese, while in the other trial it was only slightly increased. Different lots of mulberries were used in the two trials. The cheese were not rancid during the ripening and were very similar in flavor to the control cheese.

The cheese made with larger amounts of mulberry juice, from 65 to 200 ml. per 1,000 pounds of milk, showed appreciable increases in fat acidities over the control cheese and all were rancid at some stage of the ripening. At 6 months only one of the ten lots was graded as not rancid. With this lot the fat acidity was only slightly higher than with the control cheese. Different lots of mulberries showed considerable variation in their ability to hydrolyze cheese fat. In general, the white variety of berries was more active than the red variety. Lots 103 and 108 were red berries and were rather inactive, whereas lot 110 was white berries and was very active. The

cheese made with additions of mulberry juice greater than 50 ml. per 1,000 pounds of milk sometimes were considered superior in flavor to the control cheese during the early stages of ripening (approximately 1 month). However, after 3 months the cheese were graded as rancid or unclean and were inferior to the control cheese. The rancid and unclean flavors were more pronounced after 6 months. The rancid flavor obtained with addition of mulberry juice did not appear to decrease in intensity as was the case with certain of the lots of cheese made with rennet paste.

Manufacture of process cheese. Process cheese was prepared from various lots of cheese containing added lipase. Usually, 25 per cent of aged cheese containing added lipase was used in each batch. The aged cheese showed varying degrees of rancidity. The resulting process cheese was not rancid and was considered to have more cheese flavor than process cheese made by using 25 per cent of aged control cheese.

DISCUSSION

The results presented indicate a definite increase in the fat acidity of cheddar cheese made from pasteurized milk without addition of lipase. The average increase from month to month was quite uniform and there was no evidence of an acceleration in the fat breakdown. The increase in fat acidity could be due to the production of lipase by certain organisms in the cheese or to the solution in the fat of certain acids produced by organisms.

In the trials with rennet paste, the results suggest that some fat hydrolysis in pasteurized milk cheese is beneficial from the standpoint of production of cheddar cheese flavor. Variations were encountered in the fat acidities of cheese made with the same amounts of rennet paste. If larger lots of cheese had been made, there might have been more uniformity. Some method of standardization would appear desirable so that the degree of fat hydrolysis can be controlled.

A considerable difference was noted in the cheese made with rennet paste as a source of lipase and that made with added mulberry juice. The rancidity developed in cheese made with rennet paste was not as objectionable as the rancidity produced by the mulberry juice. The results suggest some selective fat hydrolysis. A slight rancidity during the early part of the ripening in cheese made with rennet paste usually disappeared later, while this commonly was not the case with cheese made with mulberry juice. These results are in general agreement with the suggestion of Lane and Hammer (3) that lipase from certain sources is not suitable for use in cheddar cheese.

Different lots of mulberry juice showed significant differences in their ability to hydrolyze cheese fat; juice from white berries being more lipolytic than juice from red berries. Increased amounts of mulberry juice did not always show an increased amount of fat hydrolysis, even when the same lots of berries were used.

The relation of fat hydrolysis to flavor in cheddar cheese is further emphasized when process cheese is made from a blend containing some cheese exhibiting fat hydrolysis. The slight rancidity, apparent in certain of the aged cheese showing rather extensive fat hydrolysis, is diluted when blended with young cheese so that the resulting process cheese does not have a rancid flavor. It is also possible that some of the free acids responsible for the rancidity may be volatilized during the processing operation.

SUMMARY

The fat acidities of cheddar cheese made from pasteurized milk without added lipase were very similar when the cheese were 3 days old. Increases occurred throughout the ripening period. The increases were not uniform with the different lots of cheese and could not be correlated with the pH of the cheese, the acidity of the whey at milling, or the moisture or fat content of the cheese. The fat acidities of cheese made with rennet extract and with rennet powder increased at approximately the same rate.

Purified butterfat, obtained from pasteurized sweet cream and held at the cheese ripening temperature (50° F.), did not increase significantly in acidity.

Addition of a small amount of rennet paste (13 to 40 grams per 1,000 pounds milk) resulted in an increase in fat acidity of the cheese. Some of the cheese showed varying degrees of rancidity early in the ripening, but this rancidity disappeared or nearly disappeared before the cheese were 6 months old. The cheese (made with rennet paste) that were not rancid were superior in flavor to the control cheese. The use of a small amount of rennet paste tended to mask the sour, acid flavor frequently encountered in the control cheese. Addition of a larger amount of rennet paste (50 to 225 grams per 1,000 pounds of milk) resulted in a significant increase in fat acidity of the cheese. All of the cheese showed rancidity at some time during the ripening and certain lots were rancid when the cheese were 6 months old.

The addition of mulberry juice to pasteurized milk did not improve the flavor of the resulting cheese. Small amounts had little effect on the flavor while larger amounts resulted in rancid and unclean flavors.

The use of a certain amount of aged cheese showing definite fat hydrolysis was beneficial from the standpoint of flavor of process cheese. Process cheese containing some aged cheese made with addition of rennet paste had more flavor than process cheese made with an equivalent amount of aged control cheese.

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SOME STUDIES OF LACTATION RECORDS

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The lactation records of 15,442 cows in dairy-herd-improvement-association herds, which had been collected from 12 states and used in a study of the influence of season on milk production(2), were available to the writer for subsequent study and analysis.

The results of three studies are given in this paper that show: 1) the influence of the month of calving on production; 2) the average lactation curves of low-, medium-, and high-producing cows; and 3) the influence of the stage of lactation on milk yield and percentage of butterfat.

INFLUENCE OF MONTH OF CALVING ON PRODUCTION

The influence of the month of calving on both the persistency of milk production and the total milk yield for the lactation period is a subject of considerable interest to dairymen and extension workers. Information on this subject would be helpful to a dairyman in deciding at what time of the year it is best to have his cows calve, in order to take advantage of market requirements and favorable prices of milk and feed.

In order to study the relationship of the month of calving to production, it was decided to sort the 15,442 DHIA records and group them according to the month of calving. Thus, one group of lactation records represented all the cows that had calved in January, another group all the cows that had calved in February, and so on for each of the 12 calendar months.

Table 1 shows the number of cows that calved in each calendar month, and the average daily milk production per cow for each month of the lactation period (4-per cent-fat-corrected basis).

The cows calved at various times during the calendar month, and most of them were in milk less than 30 days during the first month of lactation indicated in table 1. Therefore, the average daily milk yield for the first calendar month was calculated for each cow as follows: For example, if a cow calved on the 12th day of April and the cow tester found that she produced 40 pounds of milk on some one day in that month, her average daily yield for the month was considered to be $40 \times 18/30$, or 24 pounds. If she continued to give milk for 365 days, some of her production would show up in the cow tester's report for the following April. This accounts for the small production shown for the 13th month in table 1.

The total production for the lactation period was obtained by adding the average daily yields for the 13 months and multiplying by 30.42, the average number of days in a month.

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TABLE 1

Influence of month of calving upon the yield in pounds of 4-per cent-fat-corrected milk per cow per day by months of lactation

Month of calving	Number of lactation records	Month of lactation													Total for the lactation
		1	2	3	4	5	6	7	8	9	10	11	12	13	
Jan.	1,349	17.60	39.81	37.29	34.71	33.92	31.49	27.74	24.71	20.65	16.00	9.03	4.56	1.30	9,096
Feb.	1,211	16.47	39.74	37.49	36.33	33.50	29.35	26.87	23.85	20.59	15.66	9.85	5.04	1.49	9,017
Mar.	1,373	17.83	40.42	39.56	36.24	31.58	28.94	26.12	23.36	19.89	15.82	10.47	5.70	1.59	9,056
Apr.	1,029	18.23	41.75	39.20	34.02	30.92	28.34	25.91	22.69	20.52	16.97	11.05	5.77	1.68	9,042
May	925	18.57	41.57	36.81	33.38	30.52	27.86	25.19	23.51	21.29	17.87	12.04	7.01	2.33	9,070
June	846	16.92	39.02	36.58	32.71	29.71	26.86	25.51	23.90	21.54	18.37	12.84	7.91	2.61	8,964
July	885	16.14	36.84	34.80	31.67	28.85	27.64	26.19	24.32	22.24	18.74	13.94	8.49	2.05	8,886
Aug.	1,292	14.89	36.40	34.23	31.33	29.25	27.66	26.39	24.79	23.00	20.79	15.20	7.73	1.87	8,935
Sept.	1,740	15.35	37.23	34.23	32.09	30.31	28.72	27.14	25.69	24.29	20.29	12.49	6.36	1.56	9,003
Oct.	1,817	16.80	37.79	35.51	33.17	31.24	29.25	27.95	27.31	24.31	18.21	11.21	5.19	1.23	9,107
Nov.	1,534	16.48	38.94	36.67	33.84	31.43	29.91	29.56	27.14	22.34	17.26	9.81	4.67	1.15	9,108
Dec.	1,446	17.23	39.13	37.09	34.04	32.17	31.48	29.44	25.21	21.39	16.23	9.44	4.46	1.20	9,087

Figure 1, based on the data in table 1, shows the lactation curves for the cows that calved in each month. In the preparation of these curves, the production was spotted at the middle of the month when the cows were milked for a full month; but when they were milked only half a month on the average, as occurred in the month of calving, the production was spotted

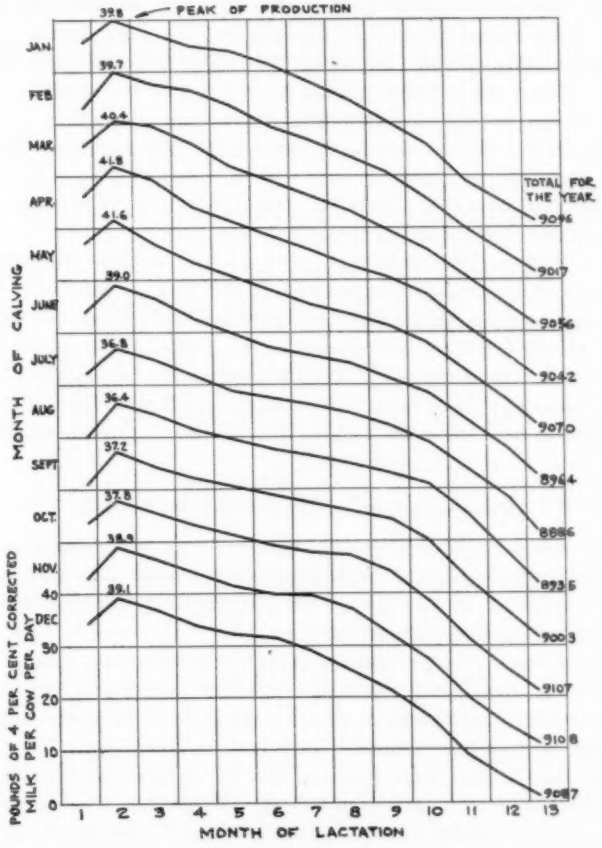


FIG. 1

at the 23d day. This necessitated doubling the yield shown in table 1 for the first month.

By examining these curves, it will be seen that the cows that calved in April reached a higher peak of production than any other group. This was because cows that calve in April are naturally at the high point of their lactation period in May or June, and these months are also the most favorable for milk production.

The cows that calved in August had a lower peak of production than any other group. This was because the high point of the lactation period for cows that calve in August comes in September or October, when conditions are the least favorable for milk production.

The cows that calved in August and September maintained their milk flow better during the latter part of the lactation period than the other groups. Cows naturally decline rapidly in milk flow during the latter part of the lactation period; but when cows calve in August and September, the latter part of the lactation period coincides with the season of the year when conditions are the most favorable for milk production.

Nearly all the curves show a flattening for the month of May. This indicates that, for the 12 states from which these records were obtained, May is the most favorable month for milk production. These results agree well with those reported by Cannon (1).

The variation in total milk production for the lactation period, between the groups calving in different months of the year, is somewhat less than might be expected, ranging from 8,886 pounds for the cows calving in July to 9,108 pounds for the cows calving in November. (See table 1.) It is evident that the total quantity of milk produced in a lactation period is not a factor of major importance for the dairyman to consider in determining the best time to have his cows freshen, if he is able to provide adequate feed for his herd at all seasons of the year.

AVERAGE LACTATION CURVES OF DHIA COWS

All the records from each State were sorted into three groups representing the low-producing cows, medium-producing cows, and high-producing cows. The records for each group were averaged by months of lactation, without regard to the month of calving.

The object was to obtain figures on the persistency of milk production which might be considered normal for low-, medium-, and high-producing cows in dairy-herd-improvement associations in each State and also for the average cow in these associations.

It was thought that such figures might be of some use to investigators in judging the merits of certain practices. Oftentimes, a satisfactory basis for comparison is lacking because of the absence of controls or checks. In such cases, the persistency of milk production as found in the better herds of the country—represented by the DHIA cows—would provide a good basis for comparison. If persistency in any herd were found to be lower than that indicated for these cows, as shown in table 2, it would perhaps be an indication of some fault in the breeding, feeding, or management practices.

Since the cows had freshened at various times during each month, they were milked on the average only about half of the first calendar month of their lactation period. This explains the low production shown for the

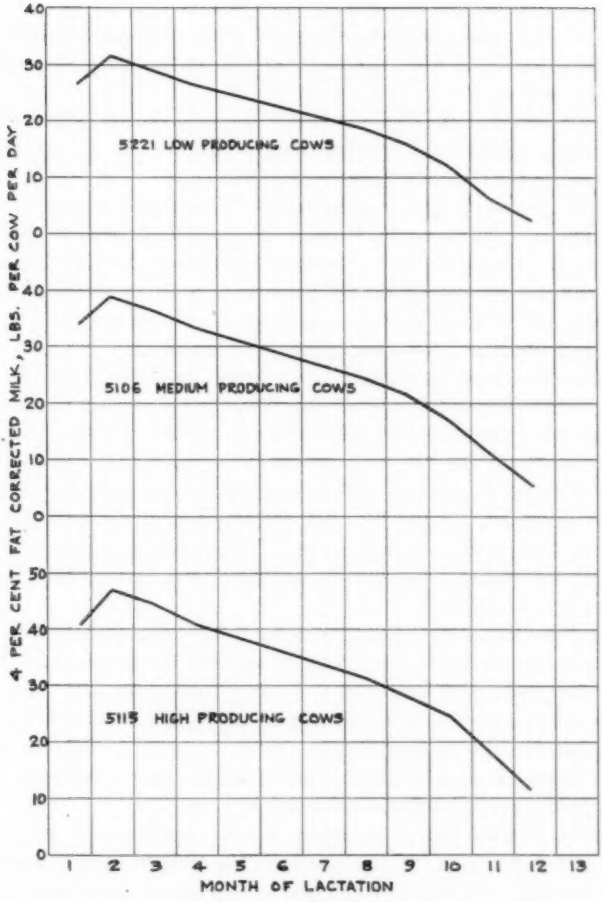
TABLE 2

Average production of 4-per cent-fat-corrected milk per cow per day by months of lactation

State	Number of lactation records	Month of lactation											
		1	2	3	4	5	6	7	8	9	10	11	12
Low-producing cows													
Calif.	433	15.5	36.5	32.5	29.1	26.7	24.5	22.5	19.9	16.8	12.4	5.3	1.4
Colo.	427	14.5	35.2	31.8	28.9	26.4	24.3	22.3	20.6	17.7	13.9	7.8	3.5
Iowa	474	12.5	32.1	29.6	27.2	24.8	22.7	20.9	18.9	16.1	12.7	8.2	4.3
Md.	294	11.6	28.6	27.1	25.2	22.9	21.6	19.9	18.0	15.4	11.9	5.4	2.2
Minn.	478	14.3	31.1	28.4	25.2	23.0	21.4	19.6	17.7	15.1	11.1	5.7	2.4
N. C.	384	11.9	25.7	24.0	21.8	20.3	18.8	17.4	15.5	13.0	8.7	4.5	2.0
N. H.	543	14.5	32.5	30.3	27.6	25.6	23.5	22.1	20.1	17.7	14.1	7.1	2.8
N. Y.	368	13.7	31.1	29.0	26.2	24.2	22.6	20.8	18.4	15.6	10.7	4.3	1.0
Ohio	559	13.4	29.6	27.3	24.7	22.6	21.0	19.5	17.3	14.7	10.5	4.9	1.8
Va.	295	10.9	29.9	27.8	25.3	23.7	22.0	20.7	18.7	17.0	14.3	8.1	3.3
Wash.	529	13.7	35.6	32.5	29.5	27.0	24.7	22.7	20.4	17.4	13.6	6.8	2.4
Wis.	437	13.4	30.2	27.7	25.2	23.3	21.3	19.8	17.8	14.6	10.9	4.6	1.0
Average		13.3	31.5	29.0	26.3	24.2	22.4	20.7	18.6	15.9	12.1	6.1	2.3
Decline from one month to next %				7.94	9.31	7.98	7.44	7.59	10.4	14.52	23.90	49.59	
Medium-producing cows													
Calif.	407	18.2	44.4	40.9	37.6	34.6	32.4	29.8	27.1	24.2	19.1	11.0	3.3
Colo.	442	18.4	44.3	41.4	37.6	34.6	32.0	30.1	27.9	24.9	20.9	14.5	8.7
Iowa	479	21.7	39.7	37.2	33.7	31.7	29.2	26.8	24.1	21.4	17.6	11.9	6.8
Md.	291	15.2	34.9	32.0	29.4	28.0	26.5	24.4	22.1	20.0	16.0	11.1	5.9
Minn.	465	17.0	37.4	34.9	31.7	29.1	27.2	24.9	22.8	20.0	16.0	10.3	5.9
N. C.	404	15.4	33.7	31.9	29.6	27.3	25.3	23.3	21.0	18.2	13.4	7.6	3.3
N. H.	486	15.2	37.0	36.8	33.6	30.9	28.7	26.8	24.6	22.0	18.2	11.8	6.0
N. Y.	356	17.2	38.8	36.8	33.2	30.7	28.8	26.9	24.4	21.0	15.4	7.9	2.3
Ohio	553	15.7	36.3	34.3	31.4	29.3	27.1	25.3	23.1	20.5	16.8	9.9	4.5
Va.	288	14.8	36.6	33.7	31.6	29.2	27.8	26.3	24.0	21.7	18.1	12.6	7.2
Wash.	476	17.4	43.8	40.5	36.6	33.5	31.1	28.8	26.4	23.5	18.8	11.7	5.4
Wis.	459	17.3	38.4	35.7	32.5	30.2	28.3	26.3	23.8	20.4	15.4	7.8	2.1
Average		17.0	38.8	36.3	33.2	30.8	28.7	26.6	24.3	21.5	17.1	10.7	5.1
Decline from one month to next %				6.44	8.54	7.23	6.82	7.32	8.65	11.52	20.47	37.43	

TABLE 2 (*Continued*)

State	Number of lactation records	Month of lactation											
		1	2	3	4	5	6	7	8	9	10	11	12
		High-producing cows											
Calif.	413	22.4	52.4	49.3	46.1	42.7	39.6	37.3	34.8	31.7	26.6	18.1	6.7
Colo.	408	22.5	55.0	52.2	48.0	44.8	41.7	39.2	36.6	33.4	30.0	24.8	18.3
Iowa	447	25.7	51.0	48.1	44.0	40.7	38.0	35.7	32.9	29.8	25.3	18.6	13.1
Md.	271	17.4	39.8	37.4	26.6	32.9	30.7	28.9	27.3	24.3	21.2	17.0	12.5
Minn.	542	19.8	46.0	43.3	40.2	37.3	34.9	32.9	30.0	27.0	23.0	16.8	11.3
N. C.	355	17.4	40.7	39.2	36.4	33.8	31.8	30.0	28.0	24.8	20.4	14.0	6.8
N. H.	472	19.5	44.0	42.6	39.5	36.5	34.2	32.2	29.9	27.2	24.0	19.0	13.0
N. Y.	379	22.2	48.6	45.0	41.2	37.9	35.4	33.8	31.0	27.2	21.4	13.8	6.9
Ohio	551	17.9	44.9	43.5	40.2	37.5	34.8	32.8	30.5	27.6	24.3	18.5	11.9
Va.	296	18.3	41.7	39.9	37.7	34.8	33.0	30.9	29.0	27.2	24.3	20.1	15.2
Wash.	487	19.2	51.8	49.6	45.6	42.7	39.5	37.0	34.4	30.7	26.1	18.8	10.4
Wis.	494	21.5	46.8	44.5	41.9	38.8	36.2	33.3	30.4	26.2	20.0	10.8	3.2
Average		20.3	46.9	44.6	40.6	38.4	35.8	33.7	31.2	28.1	23.9	17.5	10.8
Decline one month to next %				4.91	8.97	5.42	6.77	5.87	7.42	9.94	14.95	26.78	
Grand average of all		16.9	39.1	36.6	33.4	31.1	29.0	27.0	24.7	21.8	17.7	11.4	6.1
Decline from one month to next %				6.39	8.74	6.89	6.75	6.90	8.52	11.74	18.81	35.59	


5221 LOW PRODUCING COWS
5106 MEDIUM PRODUCING COWS
5115 HIGH PRODUCING COWS
4 PER CENT FAT CORRECTED MILK, LBS. PER COW PER DAY
MONTH OF LACTATION

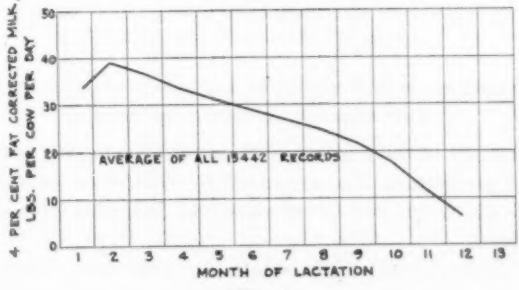

AVERAGE OF ALL 15442 RECORDS
4 PER CENT FAT CORRECTED MILK, LBS. PER COW PER DAY
MONTH OF LACTATION

FIG. 2

first month of lactation in table 2. The figures for the second month of lactation in each case represent the production at approximately 1 month after freshening; those for the third month of lactation, 2 months after freshening, and so on.

Figure 2, based on the data in table 2, shows the average lactation curves of the low-, medium-, and high-producing cows in the 12 states, also the lactation curve for the entire group of 15,442 cows.

The low-producing group averaged 6,770 pounds of milk per cow per year (4 per cent fat-corrected basis); the medium-producing group, 8,831 pounds; and the high-producing group, 11,318 pounds. At 1 month after calving, the low-producing group reached a peak production average of 31.5 pounds per cow per day; the medium-producing group averaged 38.8 pounds; and the high-producing group, 46.9 pounds.

From the time peak production was reached until 8 months after calving, when pregnancy began to affect production, the percentage declines in milk production from one month to the next were greatest for the low-producing cows and the least for the high-producing cows. The decline from one month to the next during the 8-month period averaged 8.4 per cent for the low-producing cows, 7.5 per cent for the medium-producing cows, and 6.6 per cent for the high-producing cows. The average decline in milk production for the 15,442 cows was 7.4 per cent from one month to the next, during the 8-month period.

Calculations based on the data in table 2 show that for each of the three different production levels, the range of variation in the ratio of daily milk yield to total production was least at 7 months after calving. For example, the range in the ratio for this month was only 1 : 364 for the low-producing cows; 1 : 363 for the medium-producing cows; and 1 : 363 for the high-producing cows. That is, total production for the year was 364 or 363 times 1 day's production 7 months after calving.

The most reliable time to estimate a cow's total yearly production on the basis of 1 day's milk yield is when she has been in milk 7 months. The range in the ratio of 1 day's milk yield to total production was less at that time, for all three production levels, than at any other time in the lactation period.

INFLUENCE OF THE MONTH OF LACTATION ON MILK YIELD AND ON THE PERCENTAGE OF BUTTERFAT

Since this study of the relation of the stage of lactation to the milk yield and butterfat percentage was suggested by California extension workers, records of the California cows were assembled independently of the records from all 12 states.

For the California study, 120 lactation records were selected at random from among the low producers, the medium producers, and the high pro-

TABLE 3

Influence of the month of lactation upon the milk yield and the butterfat percentage separately when the influence of month of calving is eliminated

Source of records	Number of records		Month of lactation											
			1	2	3	4	5	6	7	8	9	10	11	12
Calif.	360	Lbs. milk per cow per day	17.0	42.1	39.5	35.8	32.8	30.1	27.6	24.9	21.9	17.3	10.4	3.5
		Butterfat percentage	4.55	4.46	4.38	4.46	4.55	4.63	4.73	4.84	4.95	5.10	5.20	5.20
12 states	720	Lbs. milk per cow per day	16.4	38.6	36.6	33.1	30.7	28.1	25.7	23.4	20.1	15.4	9.6	4.9
		Butterfat percentage	4.28	4.16	4.09	4.16	4.21	4.29	4.37	4.43	4.54	4.72	4.89	4.97

ducers, making a total of 360 records from California. In addition, 60 records were selected at random from among the medium producers, in each of the 12 states, making a total of 720 records for 12 states.

To eliminate the influence of the month of calving, 10 records were taken of cows calving in each of the 12 calendar months, in the 3 California groups; and from each of the three groups in 12 states, 5 records were taken of cows calving each month. The results are shown in table 3 and figure 3.

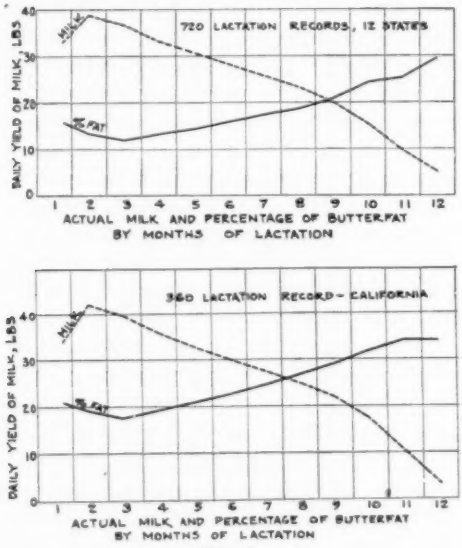


FIG. 3

It will be noted that the percentage of butterfat is lowest in the third month of lactation, after which there is a steady increase which becomes more rapid toward the end of the lactation. The milk production was greatest in the second month. Thereafter, the decline was steady until near the close of the lactation, when it became more rapid. In general, a decrease in quantity of milk is accompanied by an increase in the percentage of fat and vice versa, except that the percentage of butterfat declines along with the decline in milk yield for a short time after the peak of milk production is reached.

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THE ALKALINITY OF MILK ASH AND ITS RELATION TO THE DETECTION OF NEUTRALIZERS IN DRY MILKS. I. DRY SKIM MILK*

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Alkaline compounds are frequently added to milk and certain milk products for the purpose of adjusting the acid developed as a result of bacterial action. This practice has created the need for a suitable method of detecting these added neutralizers. Various chemical and physical methods have been developed; however, many of these are unsatisfactory either because they fail to detect relatively small amounts of neutralizers, or because they are too cumbersome in operation.

This study deals with a method recommended by Hillig (5) in 1942 for the detection of added neutralizers in dry skim milk. It was undertaken to determine the sensitivity of the method in detecting small amounts of added neutralizers in dry skim milk.

LITERATURE REVIEW

Methods for the detection of added neutralizers in milk which involve titration of the milk ash have been used for many years. In 1899 Padé (6) reported that the quantitative measurement of the alkalinity of milk ash aided in the detection and estimation of added sodium bicarbonate. Since then titrametric procedures for the estimation of ash alkalinity have been suggested by Farnsteiner (1), Pfyl (7) and Tillmanns and Bohrmann (8).

Hillig (2, 3) found that the procedure suggested by Tillmanns and Bohrmann (8) was applicable to dry skim milk. He reported values for the ash alkalinity of unneutralized dry skim milk ranging from 80 to 115, expressed as the milliliters of 0.10 normal hydrochloric acid required to titrate the ash from 100 grams of dry skim milk, whereas the ash alkalinity of neutralized dry skim milks was usually several times as great (3, 4, 5). Unfortunately, no control was reported as to the amount of neutralizer used, and the amount added may have been large in all cases.

EXPERIMENTAL METHODS

The procedure outlined by Hillig (4) for the determination of ash alkalinity was used throughout this study and is as follows:

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Carefully carbonize two grams of dry skim milk in a 50- to 100-milliliter platinum dish over a direct flame. Place the dish in a muffle oven at 550° C. for one hour. Moisten the ash with a few milliliters of water and break up the lumps with a flattened stirring rod or policeman. Dry the ash on a steam bath and then on a hot plate; and reash in the muffle oven for one hour. Cool in a desiccator and weigh.

To the ash add a few milliliters of water, break it up and transfer it completely to a 400-milliliter beaker with water. Add 50 milliliters of 0.10 normal hydrochloric acid, cover the beaker with a watch-glass, heat to boiling, and boil gently for five minutes. Cool the solution and wash off the watch-glass with recently boiled distilled water. Add 30 milliliters of a 40 per cent calcium chloride solution (neutralized with 0.10 normal hydrochloric acid and filtered) and let it stand for 10 minutes. Add 10 drops of phenolphthalein indicator and titrate the excess acid with 0.10 normal sodium hydroxide. Express results as the milliliters of 0.10 normal hydrochloric acid required to titrate the ash from 100 grams of the sample.

In the work here reported, the temperature of the muffle oven was controlled with a Wheelco Capacitrol, and variations in temperature did not exceed 18° F. (10° C.). All ash alkalinity determinations were made in duplicate, and results were reported as the averages of duplicate analyses. The titratable acidity of the fluid samples of skim milk was measured by titrating an 18-gram sample with 0.10 normal sodium hydroxide to the phenolphthalein end-point,

The skim milk was heated to 90 to 100° F. (32.2 to 37.8° C.) before the neutralizer was added. Ten per cent solutions of the neutralizer were used. After the neutralizer was added, the skim milk was heated to 150° F. (65.6° C.) for approximately 30 minutes and dried without intermediate cooling. The skim milk was neutralized and pasteurized in 10 gallon cans in a vat of water and was stirred until the desired temperature was reached.

All samples of skim milk other than those from commercial plants were dried on an atmospheric roller drier.

EXPERIMENTAL

The range of ash alkalinity values of commercial samples of dry skim milk. To determine the range of variation which could be expected in the ash alkalinity of unneutralized dry skim milk produced and processed under different conditions, samples were obtained from 24 widely separated plants in the state of Minnesota. The manufacturer was asked to submit only samples of unneutralized dry skim milk. In spite of this precaution the possibility existed that some of the samples from central drying plants contained neutralizer, since in these plants the skim milk was not always under the supervision of the operator of the drying plant.

In the course of this study 115 samples of dry skim milk were obtained

from the 24 drying plants. The ash alkalinity of these samples ranged from 66.0 to 127.0 and averaged 96.8, expressed as the milliliters of 0.10 normal hydrochloric acid required to titrate the ash from 100 grams of the sample. These values, although they are distributed over a wider range, compare favorably with those reported by Hillig (3). He reported values ranging from 80.0 to 115.0, and by calculation it was found that over 80 per cent of the values reported in the present study fell within this range. Thus, the ash alkalinity values of the 10 to 90 percentile group of these 115 samples ranged from 81.0 to 112.0.

The results demonstrated that there normally was a large variation in the ash alkalinity of skim milk from different sources. As is shown in

TABLE 1

Frequency distribution of ash alkalinities of 115 commercial samples of dry skim milk

Ash alkalinity	Frequency
*ml.**	
65– 69.5	1
70– 74.5	1
75– 79.5	6
80– 84.5	12
85– 89.5	13
90– 94.5	18
95– 99.5	19
100–104.5	18
105–109.5	11
110–114.5	10
115–119.5	4
120–124.5	0
125–129.5	2
	115

* ml. 0.10 normal acid per 100 grams. Mean—96.8 ml.

table 1, however, the ash alkalinity of a large proportion of the samples was near the mean value of 96.8.

The relationship between variations in ash alkalinity and the season of the year. The commercial samples of dry skim milk were obtained each month through a period from July 1, 1942, to July 31, 1943. Unfortunately, it was not possible to obtain an equal number of samples during each month of this period, and considerable variation in the number of samples occurred from month to month. The results of ash alkalinity determinations were averaged, however, for each month and season. No definite conclusions can be drawn from these data, as presented in table 2. The variations in the average ash alkalinities were considerable from month to month, and no definite seasonal trends were apparent.

Breed differences in the ash alkalinity of dry skim milk. Since one breed of cows is frequently predominant in a given territory, a study was made to determine whether there was a significant difference in the ash alkalinity

TABLE 2

Monthly and seasonal variations in the ash alkalinity of commercial samples of dry skim milk

	Month	Number of samples	Ash alkalinity	
			Monthly average	Seasonal average
			*ml.**	*ml.**
1942	July	8	98.1	
	August	29	100.3	
	September	2	84.0	
				99.0
	October	5	108.6	
	November	5	92.8	
	December	1	108.0	
				101.4
1943	January	12	98.3	
	February	8	99.9	
	March	6	100.5	
				99.3
	April	0	.....	
	May	13	91.0	
	June	0	.....	
				91.0
	July	26	91.7	

* ml. 0.10 normal acid per 100 grams.

of the skim milk from the milk produced by cows of three different breeds, namely Guernsey, Holstein, and Jersey. Milk was obtained from cows of the University Farm Dairy herd. In each trial the milk from not less than six cows of each breed was included, and different cows were used in each trial. The milk was separated and the skim milk was dried.

This experiment was repeated three times with results as shown in table 3. The ash alkalinity was invariably greater in the dry skim milk from Holstein milk than in the dry skim milk from Guernsey and Jersey milk, while the differences between the latter two were small.

TABLE 3

The ash alkalinity of dry skim milk from the milks produced by three breeds of cows

Breed	Trial No.	Ash alkalinity
		*ml.**
Guernsey	1	71.0
	2	64.5
	3	62.0
Holstein	1	110.5
	2	111.5
	3	95.0
Jersey	1	69.0
	2	57.0
	3	64.0

* ml. 0.10 normal acid per 100 grams.

TABLE 4

The ash alkalinity of neutralized dry skim milk

Trial No.	Lot No.	Neutralizer used	Titratable acidity of fluid skim milk			Dry skim milk	
			Desired reduction	Before neutralization	After neutralization	Ash alkalinity	Increase in ash alkalinity per 0.01 per cent desired reduction in titratable acidity
			%	%	%	*ml.**	*ml.**
	1	None	.....	0.16	0.16	94.0	.....
	2	Calcium hydroxide	0.01	0.175	0.165	106.0	12.0
1	3	Calcium hydroxide	0.02	0.18	0.16	117.0	11.5
	4	Calcium hydroxide	0.03	0.195	0.17	127.0	11.0
	5	Calcium hydroxide	0.04	0.205	0.17	143.0	12.3
	1	None	.....	0.17	0.17	78.0	.....
	2	Sodium bicarbonate	0.01	0.18	0.17	95.0	17.0
2	3	Sodium bicarbonate	0.02	0.195	0.175	108.0	15.0
	4	Sodium bicarbonate	0.03	0.20	0.17	124.5	15.5
	5	Sodium bicarbonate	0.04	0.21	0.175	133.5	13.9
	1	None	.....	0.155	0.155	87.0	.....
	2	Sodium sesquicarbonate	0.01	0.17	0.16	103.0	16.0
3	3	Sodium sesquicarbonate	0.02	0.18	0.165	111.5	12.3
	4	Sodium sesquicarbonate	0.03	0.195	0.17	116.0	9.7
	5	Sodium sesquicarbonate	0.04	0.205	0.17	125.5	9.6

* ml. 0.10 normal acid per 100 grams.

The effect of neutralization on the ash alkalinity of skim milk. After preliminary trials had been made to determine approximately the amount of added alkaline compounds which would produce a measurable increase in the ash alkalinity of skim milk, a series of experiments was performed as indicated below.

Milk from the University Farm Dairy herd was separated, and the skim milk was divided into five lots. About 0.50 per cent of an active starter culture was added to each lot. One lot which served as the control was pasteurized and dried immediately. The other lots were incubated for various periods of time until approximately 0.01, 0.02, 0.03 and 0.04 per cent acid had developed in lots 2, 3, 4 and 5, respectively. A 10 per cent solution of sodium bicarbonate was then added in amounts theoretically sufficient to reduce the titratable acidity which had developed. The skim milk was then pasteurized and dried.

This experiment was performed three times and differed only in the type of neutralizer used: sodium bicarbonate, sodium sesquicarbonate (Diversey USN) and calcium hydroxide being used in trials 1, 2 and 3, respectively. The results of analyses of the dry skim milks are presented in table 4. The increase in ash alkalinity per 0.01 per cent reduction in titratable acidity was calculated by dividing the difference in ash alkalinity between the unneutralized control and the sample in question by the desired reduction in titratable acidity.

The results demonstrated that the addition of alkaline neutralizers to skim milks in amounts sufficient to reduce the titratable acidity only 0.01 per cent caused appreciable increases in the ash alkalinity. The increases in ash alkalinity per 0.01 per cent reduction in titratable acidity were of the same order when acidities of 0.02, 0.03 and 0.04 were neutralized, even when different neutralizers were used.

SUMMARY

Samples of unneutralized dry skim milk were obtained from commercial drying plants to determine the variation which could normally be expected in the ash alkalinity, as determined by the Tillmanns-Bohrmann method. The ash alkalinity of 115 samples was found to vary within the range of 66.0 to 127.0 expressed as the milliliters of 0.10 normal hydrochloric acid required to titrate the ash from 100 grams of dried skim milk. The average ash alkalinity of these samples was 96.8. The samples of dry skim milk were obtained over a period of one year, and during that time no significant seasonal variations were apparent.

The milk from different breeds of cows was studied to determine whether there were variations in the ash alkalinity of the milk due to breed. Considerable differences were consistently found in the milk from the breeds studied. The ash alkalinity of dry skim milk from Holstein milk was

greater than the ash alkalinity of dry skim milk from Guernsey or Jersey milk.

The effect of added neutralizers on the ash alkalinity of dry skim milk was studied. It was found that when sodium bicarbonate, sodium sesquicarbonate or calcium hydroxide was added to skim milk in amounts sufficient to reduce the titratable acidity as little as 0.01 per cent, the ash alkalinity of the dry product was measurably increased. The increase produced by the three different compounds was similar. Even though the addition of alkaline compounds in amounts sufficient to reduce the titratable acidity 0.01 to 0.03 per cent caused appreciable increases in the ash alkalinity, the increases were not sufficient in most cases to cause the ash alkalinity to appear abnormal when compared with the range of values obtained on samples of unneutralized dry skim milk.

CONCLUSIONS

1. The ash alkalinity of unneutralized skim milk varies within a wide range.

2. There are considerable differences in the ash alkalinity of the skim milk from the milk of different breeds of cows.

3. The addition of alkaline compounds to skim milk in amounts sufficient to reduce the titratable acidity as little as 0.01 per cent produces measurable increases in the ash alkalinity.

4. Because of the normal variation in the ash alkalinity of unneutralized skim milk, it may be possible in some cases to reduce the titratable acidity considerably more than 0.01 per cent by the addition of alkaline compounds without causing the alkalinity of the resulting product to appear abnormally high as compared with the range of values obtained on unneutralized skim milk.

5. Calcium hydroxide, sodium bicarbonate, and sodium sesquicarbonate produce similar increases in the ash alkalinity of skim milk when they are added in amounts sufficient to neutralize equal amounts of acid.

ACKNOWLEDGMENTS

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THE ALKALINITY OF MILK ASH AND ITS RELATION TO THE DETECTION OF NEUTRALIZERS IN DRY MILKS. II. DRY BUTTERMILK*

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This study was undertaken to determine the applicability to dry sweet cream buttermilk of the method recommended by Hillig (1) for the detection of added neutralizers in dry skim milk.

EXPERIMENTAL METHODS

The ash alkalinity of dry buttermilk was determined by the method used for the detection of neutralizers in dry skim milk as outlined in a previous paper (3).

The procedure used in preparing the buttermilk was quite uniform. Sweet cream was standardized to contain 30 per cent fat. It was pasteurized at 165° F. (73.9° C.) for 30 minutes and was then cooled to below 50° F. (10° C.). Pasteurization and cooling was usually carried out in a horizontal coil vat. The cream was held overnight in the vat and was churned at 48 to 55° F. (8.9 to 12.8° C.), the lower temperature being used in the summer months.

EXPERIMENTAL

The ash alkalinity of unneutralized dry sweet cream buttermilk. The approximate range of ash alkalinity of dry sweet cream buttermilk was established by analyses of samples of dry sweet cream buttermilk which were prepared during the course of the studies here reported and which were definitely known to contain no neutralizer.

The buttermilk was not separated before drying and the fat content of the fluid buttermilk, as determined by the normal butyl alcohol test (2), was below 0.60 per cent in all cases. The ash alkalinity of 16 samples ranged from 55 to 112, and averaged 78.0, expressed as the milliliters of 0.10 normal hydrochloric acid required to titrate the ash from 100 grams of dry buttermilk.

The ash alkalinity of commercial samples of dry buttermilk. A total of 90 samples of dry buttermilk were obtained from 6 drying plants in Minnesota. The ash alkalinity of these samples ranged from 110 to 673, and

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averaged 238. The distribution of the samples in this range is shown in table 1.

Breed differences in the ash alkalinity of dry sweet cream buttermilk. In a previous study it was found that the ash alkalinity of dry skim milk from Holstein milk was greater than the ash alkalinity of dry skim milk from Guernsey or Jersey milk (3). To determine whether differences were apparent in buttermilk, the milk from cows of these three breeds was separated and the three lots of cream were churned. The fat content of the fluid buttermilks was between 0.45 and 0.55 per cent as determined by the normal butyl alcohol test (2). The buttermilk from each lot was dried on an atmospheric roller drier. The ash alkalinities were 59, 88 and 55 for dry buttermilks from Guernsey, Holstein and Jersey milk, respectively.

TABLE 1

Frequency distribution of ash alkalinities of 90 commercial samples of dry buttermilk

Ash alkalinity	Frequency
*ml.**	
100–149.5	13
150–199.5	29
200–249.5	20
250–299.5	9
300–349.5	8
350–399.5	5
400–449.5	2
450–499.5	1
500 and over	3
	90

* ml. 0.10 normal acid per 100 grams.

The effect of neutralization on the ash alkalinity of buttermilk. Three experimental trials were made in which the buttermilk churned from sweet cream was neutralized using various alkaline compounds. In each trial cream obtained from a local distributor was churned and the buttermilk divided into thirteen lots. A small amount of an active starter culture was added to each lot. One lot, which served as a control, was pasteurized and dried immediately. Each of the other lots was incubated at about 80° F. (26.7° C.) to encourage the development of lactic acid. When the desired amount of acid had developed in a lot a 10 per cent solution of one of four alkaline compounds was added in an amount theoretically sufficient to neutralize the developed acidity. The alkaline compounds used in these trials were Absorbex M, calcium hydroxide, magnesium oxide and sodium hydroxide. Each compound was used to neutralize three lots of buttermilk containing 0.01, 0.02 and 0.03 per cent developed acidity. After the addition of the neutralizer, each lot of buttermilk was heated to 150° F. (65.6° C.) for about 30 minutes and was dried. In Trials 1 and 2 the buttermilks

TABLE 2

The ash alkalinity of neutralized dry buttermilk

	Neutralizer used												
	None	Absorbex M*			Calcium hydroxide			Magnesium oxide			Sodium hydroxide		
Desired reduction in titratable acidity, %	0	0.01	0.02	0.03	0.01	0.02	0.03	0.01	0.02	0.03	0.01	0.02	0.03
Trial 1—Atmospheric Roller Dried													
Titratable acidity before and after neutralization, %	0.135 0.135	0.155 0.14	0.15 0.13	0.165 0.135	0.145 0.14	0.155 0.14	0.17 0.14	0.155 0.145	0.15 0.135	0.165 0.14	0.155 0.145	0.15 0.135	0.16 0.135
Ash alkalinity, ml.†	74.0	88.0	97.0	111.0	86.0	88.0	102.5	91.0	96.0	98.0	87.5	93.0	96.5
Increases in ash alkalinity per 0.01% desired reduction in titratable acidity, ml.	.....	14.0	11.5	12.3	12.0	7.0	9.5	17.0	11.0	8.0	13.5	9.5	7.5
Trial 2—Atmospheric Roller Dried													
Titratable acidity before and after neutralization, %	0.125 0.125	0.13 0.115	0.14 0.115	0.16 0.12	0.13 0.12	0.145 0.12	0.16 0.13	0.13 0.125	0.14 0.13	0.16 0.14	0.13 0.12	0.14 0.125	0.16 0.135
Ash alkalinity, ml.†	75.0	93.5	102.5	113.5	84.0	103.0	119.0	85.5	94.0	101.5	89.5	95.0	108.0
Increases in ash alkalinity per 0.01% desired reduction in titratable acidity, ml.	.....	18.5	13.8	12.8	9.0	14.0	14.7	10.5	9.5	8.8	14.5	10.0	11.0
Trial 3—Spray Dried													
Titratable acidity before and after neutralization, %	0.14 0.14	0.155 0.145	0.16 0.145	0.175 0.145	0.155 0.15	0.16 0.15	0.175 0.15	0.155 0.145	0.16 0.145	0.175 0.155	0.155 0.145	0.16 0.145	0.175 0.15
Ash alkalinity, ml.†	78.0	85.5	108.0	116.0	84.5	108.0	103.5	88.0	92.0	116.0	86.5	96.5	106.5
Increases in ash alkalinity per 0.01% desired reduction in titratable acidity, ml.	.....	7.5	15.0	1.27	6.5	15.0	8.5	10.0	7.0	12.7	8.5	9.3	9.5

* Product of Tubbs Company, River Falls, Wisconsin.

† ml. 0.10 normal acid per 100 grams of dry buttermilk.

were dried on an atmospheric roller drier, and in Trial 3 they were dried in a spray dryer.[1]

The results as presented in table 2 indicated that the addition of alkaline compounds to buttermilk in amounts theoretically sufficient to reduce its titratable acidity as little as 0.01 per cent consistently produced appreciable increases in the ash alkalinity. Although the increases in ash alkalinity per 0.01 per cent reduction were of the same order when various amounts of different neutralizers were added, there was some variation in the different trials even when the same neutralizer was added in equal amounts.

The effect of neutralizing cream on the ash alkalinity of buttermilk. One trial was made in which cream was neutralized. Sweet cream obtained from a local distributor was divided into three lots. The first lot was pasteurized and churned without further treatment. The second lot was incubated at 80 to 90° F. (26.7 to 32.2° C.) until about 0.05 per cent acid had developed.

TABLE 3

The ash alkalinity of buttermilk churned from sweet cream and from soured cream neutralized with sodium bicarbonate

Lot No.	Titratable acidity of cream			Buttermilk		
	Desired reduction	Before neutralization	After neutralization	Fat	Ash alkalinity	Increase in ash alkalinity per 0.01% desired reduction of acid in cream
	%	%	%	%	ml.*	ml.
1	none	0.17	0.17	0.38	79.0	.....
2	0.05	0.22	0.16	0.50	134.5	11.1
3	0.10	0.26	0.165	0.44	207.0	12.8

* ml. 0.10 normal acid per 100 grams of dry buttermilk.

A 10 per cent solution of sodium bicarbonate was then added in amounts theoretically sufficient to neutralize the developed acidity, and the cream was then pasteurized, cooled and churned. In the third lot 0.10 per cent acid was allowed to develop, following which the procedure was the same as in Lot 2. The buttermilk from each lot was dried shortly after churning. It was apparent from the results of analyses presented in table 3 that the addition of neutralizer to the cream caused appreciable increases in the ash alkalinity of the buttermilk. The increase in ash alkalinity per 0.01 per cent reduction in titratable acidity by the addition of neutralizer to the cream was of the same order as the increase in ash alkalinity produced by the same neutralizer when added directly to buttermilk.

SUMMARY

The ash alkalinity of 16 samples of unneutralized dry sweet cream buttermilk ranged from 55.0 to 112.0 and averaged 78.0, expressed as milliliters

[1] The spray drier used in this experiment was a pilot experimental drier designed by Dr. S. T. Coulter of the Dairy Division of the University of Minnesota.

0.10 normal hydrochloric acid required to titrate the ash from 100 grams of the sample.

The ash alkalinity of 90 commercial samples of dry buttermilk ranged from 110 to 673 and averaged 238.

The ash alkalinity of dry buttermilk from Holstein milk was considerably greater than that of dry buttermilk from Guernsey and Jersey milk.

The addition of relatively small amounts of either Absorbex M, calcium hydroxide, magnesium oxide or sodium hydroxide to buttermilk before drying caused measurable increases in the ash alkalinity of the dried product. The increases produced by the various compounds were of the same order when they were added in equivalent amounts.

The addition of sodium bicarbonate to cream produced increases in the ash alkalinity of the buttermilk churned from the cream which were comparable to the increase produced by the addition of the same amount of this neutralizer directly to buttermilk.

Even though the increases in ash alkalinity produced by the addition of neutralizer in amounts sufficient to reduce the titratable acidity of buttermilk or cream 0.01 to 0.03 per cent were measurable, they were usually not great enough to make the ash alkalinity of the dried buttermilk appear abnormal as compared with the range of values obtained on samples of unneutralized dry buttermilk. This was due largely to the fact that the original unneutralized buttermilk used in these experiments was quite low in ash alkalinity.

CONCLUSIONS

1. The ash alkalinity of buttermilk varies within a wide range. The breed of the cow producing the milk from which the buttermilk is obtained is one factor responsible for this wide range.

2. The addition of alkaline compounds to buttermilk in amounts sufficient to reduce the titratable acidity as little as 0.01 per cent produces measurable increases in the ash alkalinity.

3. The addition of neutralizer to cream is as readily detectable in the buttermilk churned from it as is its addition directly to the buttermilk.

4. The method recommended by Hillig (1) for the detection of neutralizers in dry skim milk appears to be equally adaptable to dry buttermilk. The normally wide range in the alkalinity of milk ash makes the method less sensitive in both applications.

ACKNOWLEDGMENTS

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FURTHER STUDIES OF THE EFFECT OF DILUTION RATE ON THE FERTILITY OF BULL SEMEN USED FOR ARTIFICIAL INSEMINATION

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In continuation of studies previously reported (7), an investigation has been made into the effects of increased dilution of bull semen with yolk-citrate upon its fertility when used for routine artificial insemination. In the earlier investigation the highest rate of dilution employed for insemination was 1:16. At that rate of dilution, on the average, 74 millions of spermatozoa had been used for each insemination. No difference in fertility for that rate of dilution as compared to lower rates was found. In the present investigation dilution rates of 1 part of semen to 8, 12, 16, 24 and 50 parts of the diluent were used. The number of spermatozoa inseminated at the 1:50 rate of dilution was, on the average, 26 millions. This latter rate was chosen as the highest desirable level for it was felt that substantial decreases in conception rate might be obtained above the rate of dilution previously used.

Munro (6) reported that optimum levels of fertility for the fowl required about 100 millions of spermatozoa. In a study of 200 fertile men no counts were observed below 20 millions per cc. by Hotchkiss *et al.* (4), although 25 per cent of the samples analyzed were below a count of 60 million spermatozoa per cc., with average ejaculates of between 2 and 3 cc. Walton (9) had reported earlier that the size of litters in rabbits was not decreased until the number of spermatozoa inseminated into the vagina was below 1 million per 3 cc. No fertile matings resulted when less than 10,000 spermatozoa were inseminated into the vagina.

If good results were obtained at the highest dilution rate, it appeared that diluting one volume of semen with fifty volumes of yolk-citrate would provide all of the diluted semen needed for routine insemination under most circumstances, and would make it possible to sample the bulls available no more frequently than was necessary to keep them producing semen of high quality.

EXPERIMENTAL

The experimental design employed for this investigation was the same as that previously described (7), except that the Latin squares were 5×5 squares rather than the 6×6 squares previously employed. Two groups of bulls, bull blocks A and B, each composed of 5 bulls, were used. Bulls were selected that varied widely in fertility in order that the results might be used as a recommendation of practice on a fairly wide basis. The first experi-

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ment (I), when completed at the end of 5 one-week collection periods, was immediately followed by a second (II) or replicate experiment. Thus there were to be 25 collections of semen in each of the Latin squares, or a total of 100, with 20 collections used at each dilution rate.

In general, it was planned to collect but one semen ejaculate at each collection period. Occasionally, however, the first collection proved to be nonmotile on microscopic examination. Then, a second ejaculate was collected a few minutes later and used in the experiment. Several times during the experiment, and then only when the experimental plan called for one of the lower rates of dilution, two semen samples were obtained from one bull at a collection period. These double samples were mixed before dilution and considered as one sample in the data. No semen samples containing less than 1,000,000 spermatozoa per mm.^{3}, or in which less than 50 per cent of the spermatozoa were progressively motile, were used in this experiment. However, the only specification which was established before the experiment was that each sample used was to contain motile spermatozoa.

Two different bulls, both in bull block B, refused service during one or another of the collection periods. In the case of one bull it was when the schedule called for that semen sample to be diluted at the rate of 1:8; with the other it was both when the 1:8 and the 1:16 rate was specified. For the statistical analysis, values for the particular vacant cells in the Latin square were calculated by standard methods (5) and the appropriate number of degrees of freedom subtracted from the totals. Such calculated values, however, do not appear in any of the tables nor are they used as a basis for the discussion.

It was believed that inherent differences in fertility between bulls, time trends in fertility of the bulls, or bias due to arbitrary selection of which particular samples of semen would be diluted at any particular rate could be eliminated by a planned schedule of treatment such as was made mandatory by the design used.

It was found that, as far as measurable characteristics denoting quality of semen were concerned, the design had achieved its purpose. Analysis of variance (8) of the data on the quality of the semen, including spermatozoa count, initial percentage of motile spermatozoa, and methylene-blue reduction time (1), revealed no significant differences between dilution rates for these semen characteristics. However, the significant differences found between bull blocks, among the bulls within the blocks, and certain statistical interactions, indicated that semen of considerable variability had been used in these investigations.

The mean data concerning the semen produced by the bulls used in the 4 Latin squares are shown in table 1. Each figure is a mean of 5 ejaculates except for bull block B in experiment II, where the mean is for 3 ejaculates in the case of the 1:8 rate of dilution and 4 in the case of the 1:16 dilution.

The semen was collected, handled before shipment and shipped to the 30 member units of the New York Artificial Breeders' Cooperative, Inc., by the methods previously described (7). One ml. of diluted semen, or in some cases a smaller volume, was used for insemination into the uterus. The rate of dilution of the semen samples was not known to the 32 different inseminators involved in this study. They were free to decide whether or not any particular sample was to be used for insemination, and daily made a choice by microscopic examination as to what semen samples were to be used that day.

TABLE 1

Mean data concerning the semen used in the 4 Latin squares

Experiment	Block		Ratio of semen to diluter				
			1:8	1:12	1:16	1:24	1:50
			Actual volume semen per ml.				
			0.11	0.077	0.059	0.04	0.0196
I	A	Count/mm.³ (1,000's)	1,417	1,569	1,417	1,439	1,434
		Motility %	79	80	76	81	81
		Methylene blue test (min.)	4.30	3.55	3.82	3.50	3.80
	B	Count/mm.³ (1,000's)	1,242	1,324	1,278	1,335	1,233
		Motility %	77	78	79	77	73
		Methylene blue test (min.)	5.20	4.55	4.40	4.57	5.90
II	A	Count/mm.³ (1,000's)	1,347	1,282	1,329	1,377	1,377
		Motility %	73	75	79	76	76
		Methylene blue test (min.)	4.25	3.80	3.55	3.85	3.85
	B	Count/mm.³ (1,000's)	1,372	1,384	1,404	1,259	1,254
		Motility %	81	81	78	78	78
		Methylene blue test (min.)	3.50	3.80	3.78	4.55	4.27

The inseminators daily received shipments of semen from the laboratory. Thirty-three bulls, ten of which were in this experiment, were used by the Cooperative during this period. Thus the inseminators received diluted semen regularly from twenty-three other bulls when this experiment was being conducted. Most of the semen from these bulls was diluted at lower rates than the samples used in the experiment, the highest rate ever used for these bulls during this time being 1:20. Thus the diluted semen used in the present study was in daily competition with semen from other bulls, for the approval of the individual inseminators.

The time interval during which this investigation was conducted (April, May, June, and July, 1943) was the peak of the spring breeding season—in fact, June of that year was the peak month; but there was need for not nearly so much diluted semen as was available during the period when these high dilutions were made. The amounts of semen shipped to the individual inseminators were largely fixed by the demand for semen rather than by the

amounts available. The total amounts shipped for each dilution rate during the entire investigation are given in table 2. This table also shows the amount of diluted semen available, the total amount of semen actually inseminated and the proportion of the total semen received by the inseminators which was used for insemination.

It can readily be seen that the enormous potential expansion of artificial insemination by means of increased dilution was not used to advantage during this experiment.

This table shows why the number of inseminations at each dilution does not increase in direct ratio to the amount of diluted semen available. It also suggests that the efficiency of utilization of semen in artificial breeding units is still probably at a fairly low level.

TABLE 2

Use of diluted semen obtained in the investigation

	Ratio of semen to diluter				
	1:8	1:12	1:16	1:24	1:50
Volume diluted semen available, ml.	1,562	2,067	2,814	3,962	7,166
Volume diluted semen shipped, ml.	1,333	1,663	2,004	2,321	2,293
Volume diluted semen inseminated, ml.	469	623	714	796	694
% of shipped semen used for insemination	35.2	37.5	35.6	34.3	30.3

RESULTS

Field studies of fertility. The methods used for determining the success of each insemination are described elsewhere (7). Elliott (3) has shown that cows being inseminated for the first time within any given breeding period are more likely to conceive than cows which have returned to service once and are inseminated for the second time. Second service cows represent a group that has gone through one selective process. Thus, in order to determine whether or not the relative proportion of first service or second service cows bred might influence the results, the data were studied with this fact in mind.

Table 3 presents the mean results for each dilution rate by bull blocks, by experiments and whether it was used to breed first service or second service cows. The data are presented as the percentage of services which resulted in apparent conception, and the number of services upon which the percentage figure is based.

In general, the semen at each dilution rate was used to inseminate slightly less than one-half as many second service cows as first service cows. However, it is interesting to note in table 3 that, in the case of both the 1:24 and the 1:50 rates of dilution, somewhat over one-half as many second service cows as first service cows were inseminated with the semen diluted at those rates. Also, during experiment II the semen from the bulls in block B

was used to breed 64.6 per cent as many second service cows as those being inseminated for the first time.

It can be seen in table 3 that, while there was considerable variability in the data, no definite trend in results can be attributed to the various dilution rates used. The lowest conception rate for the entire study was obtained for the 1:16 ratio of semen to diluter, the highest for the 1:12. The other values were intermediate.

To determine whether or not the differences in conception rates were statistically significant for the several categories of classification, an analysis of variance was made of the four Latin squares using the results from first and second service cows as separate entities. Thus, there were two separate observations for each ejaculate. The analysis was made of the unweighted percentage of cows bred which did not return to service for at least five months after breeding.

In the earlier study (7) it was considered necessary to weight the percentage data for each ejaculate by the number of services for that particular ejaculate, because the number of services per ejaculate varied so widely. Such an analysis is laborious and tricky. In the present case, considering first service and second service cows separately, there were only 10 instances out of 194 observations where the diluted semen was used to inseminate less than 5 cows. Only three ejaculates were used to inseminate less than 6 first and second cows combined. In view of these facts and Cochran's (2) recommendation it was not considered necessary to make an analysis of weighted percentages.

The analysis of variance showed no significant differences between the results from the five different dilution rates. The difference in fertility for first service and second service cows was not statistically significant, though the actual value, 4.7 percentage units, approached in magnitude the value of 5.3 percentage units difference shown by Elliott (3) in more extensive data. There were highly significant differences in fertility between the two bull blocks and among the bulls within each block. The bulls varied in fertility from 30.0 to 61.5 per cent. In no case was there evidence to indicate that the level of fertility for any bull decreased with increased dilution of the semen. Thus these results may be considered primarily as a reflection of the fertility level of the bulls used. The average fertility for block A was 53.5 per cent non-returns for the entire experiment and 52.4 per cent for the 1:50 rate of dilution. The comparable figures for block B were an average of 40.5 per cent non-returns for the entire experiment and 41.8 for the 1:50 dilution rate.

Duration of fertility. In the first investigation (7) on this general problem it was shown that livability of spermatozoa stored in the yolk-citrate diluter progressively decreased with each increase in dilution rate. To determine whether or not fertility duration followed this same pattern, the

TABLE 3

Fertility of the diluted semen by bull blocks, by experiments and whether bred to first service or second service cows

	Ratio of semen to diluter										Total	
	1:8		1:12		1:16		1:24		1:50			
	S*	% C*	S	% C	S	% C	S	% C	S	% C	S	% C
Bull Block A												
Expt. 1												
1st service cows	77	46.8	121	66.1	130	65.4	145	60.7	154	57.1	627	60.1
2nd " "	36	50.0	53	54.7	58	53.4	63	39.7	53	54.7	263	50.2
Expt. 2												
1st service cows	109	52.3	106	50.9	151	47.0	165	53.9	163	49.7	694	50.7
2nd " "	45	55.6	49	53.1	65	36.9	83	54.2	80	47.5	322	49.1
Bull Block B												
Expt. 1												
1st service cows	84	57.1	97	45.4	105	42.9	123	31.7	55	50.9	464	44.0
2nd " "	34	35.3	46	39.1	44	47.7	58	41.4	40	35.0	222	40.1
Expt. 2												
1st service cows	52	34.6	91	46.2	108	32.4	90	35.6	86	41.9	427	38.2
2nd " "	32	53.1	60	30.0	53	34.0	69	43.5	63	38.1	277	38.6
Total												
1st service cows	322	49.4	415	53.0	494	47.8	523	47.4	458	50.9	2212	49.5
2nd " "	147	49.0	208	43.8	220	42.7	273	45.4	236	44.5	1084	44.8
Total												
Combined data	469	49.3	623	49.9	714	46.2	796	46.7	694	48.7	3296	48.0

* S = services. % C = % conception based on 5 months' non-returns.

TABLE 4

Combined data (5 mos. non-returns), arranged according to day of insemination, and rate of dilution

Day of insemination	Ratio of semen to diluter												% total inseminations each day	
	1 : 8		1 : 12		1 : 16		1 : 24		1 : 50		Total		10 bulls this experiment	23 other bulls
	S	%	S	%	S	%	S	%	S	%	S	%		
1	7	28.6	15	20.0	2	50.0	12	66.7	7	57.1	43	41.9	1.3	0.8
2	328	52.4	394	52.3	455	48.1	496	47.0	491	48.3	2164	49.3	65.7	62.4
3	108	44.4	174	50.6	225	41.3	231	44.6	172	49.4	910	45.8	27.6	29.3
4	18	33.3	29	34.5	23	52.2	34	52.9	16	56.3	120	45.8	3.6	5.3
5	4	25.0	9	33.3	5	40.0	14	28.6	2	100.0	34	35.3	1.0	1.4
6	2	50.0	.....	.....	2	50.0	6	66.7	4	25.0	14	50.0	0.4	0.5
7	1	100.0	2	50.0	.....	.....	3	66.7	2	0.0	8	50.0	0.2	0.1
8	.....	.....	.....	.....	2	100.0	.....	.....	.....	.....	2	100.0	0.06	0.2
9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	1	0.0	.....	.....	.....	.....	.....	.....	.....	.....	1	0.0	0.03	.....
Total	469	49.3	623	49.9	714	46.2	796	46.7	694	48.7	3296	48.0	.....	.....
Ave. No. sperm per. insem. (millions)	150	.....	104	.....	80	.....	54	.....	26	.....	.....	.....	.....	.....

data for each ejaculate were arranged according to the day on which insemination took place, the day of collection being considered as the first day. The combined data for each dilution rate are shown in table 4. The table shows the number of services made on each day with semen diluted at each rate and the percentage of such services rsulting in apparent pregnancy.

There appeared to be no adequate method of testing statistically whether or not one dilution rate was used successfully over a longer period of time than another. Thus no test was made. Observation of the data suggested that there were no important differences between dilution rates in this regard. However, taking the investigation as a whole, 93.3 per cent of all inseminations was made on the second and third day following collection. Only 5.3 per cent of the total number of inseminations took place four or more days after collection.

In the earlier investigation (7), where lower dilution rates were compared, 1:4 up to 1:16, 84.1 per cent of the total inseminations were made on the second and third days. Nearly 12 per cent of the inseminations took place four or more days after the semen was collected. The two experiments mentioned were conducted 12 months apart. Thus it was impossible to determine whether or not the difference in proportion of services occurring four or more days after the semen was collected in the two studies was due to the greater dilutions used in the present experiment or to a change in field practice. To check this matter further, a study was made of the number of days the semen produced by the twenty-three other bulls of the Cooperative during the same period of time was used. As stated earlier no dilutions above 1:20 were employed, and most of them varied from 1:8 to 1:12. The information obtained is presented in comparison with the same data for the total experiment in the last columns of table 4. It would appear that there was no important difference in the duration of use of the semen from the bulls in the experiment or the bulls not in the experiment during the period covered by the present investigation.

DISCUSSION

Published (7) and unpublished work from our laboratory shows that semen handled in the usual way decreases in ability to live under low-temperature storage conditions with each increase in dilution rate. This so-called "dilution effect" has been observed under a variety of handling techniques, and a method of treatment has not yet been devised to prevent it. When the present investigation was planned, it was believed that the dilution effect on livability might be observed in the day-to-day microscopic examination by the individual inseminators and the semen not be used at the higher dilutions for as long as at the lower dilutions. The most important evidence to support the view that this occurred is to be found in table 2, which shows a tendency for a lower percentage of the shipped semen to be

used for insemination when diluted at the highest rate. On the other hand, from table 4 one would conclude that there was no great indication that, on the average, the semen diluted at the 1:50 rate was used differently than semen diluted at the other rates.

From the fact that no significant differences in fertility were shown between dilution rates, it would appear that the diluted semen was not used for so long a period after collection for the dilution effect to manifest itself in decreasing fertility at the highest rates of dilution used. It is possible that, had the semen at all rates of dilution been used for a longer time after collection, a difference in fertility between the dilution rates might have been observed.

SUMMARY

In a study involving 3,296 inseminations, dilution rates of 1 part of semen to 8, 12, 16, 24 and 50 parts of yolk-citrate diluter were compared. The experiment was designed so as to eliminate all arbitrary selection of the semen to be used at any dilution rate. On the average, the following number of spermatozoa were contained in the 1 ml. of diluted semen used for each insemination: 150, 104, 80, 54 and 26 millions. No statistically significant differences were found in fertility of the semen for the 5 dilution rates compared. The semen diluted at the highest rate was not used as efficiently as the semen diluted at the lower rates, but, on the average, seemed to maintain its fertility as well for 4 days after collection.

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A ROUTINE SEMIMICRO METHOD FOR THE DETERMINATION OF COPPER IN WHOLE MILK POWDER

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Iron and phosphates usually interfere with the determination of copper in milk. Gebhardt and Sommer (6), McFarlane (10), Conn and co-workers (3), Elvehjem and Lindow (5) and others have precipitated copper from an ashed sample of milk as the sulphide in order to separate the metal from these constituents.

Greenleaf (8) reported that the preliminary separation of copper from cobalt and nickel could be made either by hydrogen sulphide treatment or by extraction with dithizone at a pH of 2. Neither step entirely eliminated interference from bismuth, which precipitated with copper in the hydrogen sulphide separation and is extracted with dithizone. The interference due to the presence of bismuth was eliminated by the dithizone method proposed by Bendix and Grabenstetter (2).

Drabkin (4) reported that the contamination of copper by nickel, cobalt or bismuth in most biological materials of animal origin would be so small that it would not produce a serious error in the determination of copper by sodium diethyldithiocarbamate.

The carbamate reagent seemed to be the most desirable for the determination of copper in whole milk powder because it is extremely sensitive (11) and is almost specific for copper.

After a series of preliminary studies a method was developed which employed the principles suggested by Haddock and Evers (9). This method recommended the addition of citric acid and ammonia to the solution of the ashed sample containing iron in the ferric condition.

It was found possible to eliminate any interference due to phosphates or iron although it is known that bismuth, cobalt or nickel, if present, will interfere with this determination (4).

REAGENTS USED

Nitric acid and ammonium hydroxide C.P. The small amounts of these reagents used made it unnecessary to free them from traces of copper.

Citric acid. A 50 per cent solution of a U.S.P. grade was used; and traces of copper, if present, may be removed by adding carbamate and extracting the copper complex with isoamyl alcohol.

Sodium diethyldithiocarbamate. Dissolve 1 gram in a small amount of redistilled water, filter and dilute to a liter. More concentrated solutions deteriorate rapidly, especially if stored where they are exposed to light.

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Pyrex Vycor evaporating dishes—45 ml. Boil clean dishes in 1 : 1 nitric acid and rinse thoroughly with copper-free water. Dry dishes in 100° C. oven and store in a desiccator.

Isoamyl alcohol. Redistill from Pyrex glassware. Carbon tetrachloride, bromo benzene or isoamyl acetate may be used as the solvent for extracting the carbamate complex. This is mostly an individual preference according to the results of Greenleaf (7). However, the use of a solvent with low vapor pressure is an advantage because it can be used without special precautions to prevent evaporation.

Hydrochloric acid C.P. Dilute one volume of hydrochloric acid with an equal volume of redistilled water.

General precautions. Distilled water must be redistilled from Pyrex glassware. All glassware used must be cleaned, rinsed with nitric acid, and the acid removed by rinsing with copper-free water. All reagents may be purified if desired, but blank determinations indicated that a negligible amount of copper was introduced in this manner.

METHOD

Weigh a Pyrex Vycor evaporating dish with a watch glass for cover. Add approximately five grams of whole milk powder and weigh rapidly.

After weighing the samples, char them on a hot plate until they cease, or almost stop, smoking. This usually requires from 45 minutes to one hour. Samples are charred with the hot plate on high heat and the dishes directly in contact with the heating surface. The surface of the plate should be kept clean by occasionally polishing with pumice stone.

After charring, the samples are placed in the muffle furnace and the temperature taken rapidly to 500° C. with the door of the furnace left open. This procedure requires about 20 minutes and facilitates ashing the samples. The bottom of the furnace was covered with a piece of asbestos approximately one-quarter inch thick, which prevented the dishes from being directly in contact with the heating surface.

After the furnace has attained a temperature of 500°, the door is closed and this temperature maintained until ashing is completed. Samples are usually left in the furnace for 30 minutes after all traces of carbon have been burned from the surface of the dish. This usually requires from one and one-half to two hours.

The entire ashing operation may be carried out in the muffle furnace if desired but if this is done the door of the furnace should be left open until most of the organic material in the samples has been destroyed. This procedure is objectionable however as it causes a heavy deposit of carbon on the dishes which is difficult to remove and consequently prolongs the ashing time.

After ashing, the dishes are removed from the furnace and allowed to cool. One ml. of nitric acid is added to each sample, and they are placed

on the hot plate (low heat) and taken to dryness. Samples are replaced in the furnace (approximately 3–400°) and left for 10 to 15 minutes, or until the ash is perfectly white and no traces of carbon are present. If any carbon is present after this treatment, the process must be repeated; but it should not be necessary if the original ashing is carried far enough. The nitric acid treatment is desirable because it avoids filtering and reashing, which is a possible source of error due to loss of solution and contamination.

For routine work it is convenient to shut the furnace off after samples are ashed because, by the time the nitric acid treatment is completed, it will have cooled to about 400°. The temperature should not exceed this because traces of the acid are often present in the milk ash and spattering may cause some loss of sample.

If ashing has not been carried far enough, the carbon will be present in lumps; and when acid is added, evaporated and the samples placed in the furnace, local overheating and deflagration will result.

After the nitric acid treatment, remove samples from the furnace and cool. Add two ml. of 1–1 HCl and place on the hot plate (low heat) for several minutes, occasionally carefully rotating the contents of the dish. Add redistilled water (5 to 10 ml.) and heat for a few minutes. The ash should go readily into solution after the addition of water.

Cool and transfer the contents of the Vycor dish to a 125-ml. glass-stoppered Erlenmeyer flask. Add 5 ml. of citric acid solution and a small piece of litmus paper. Neutralize with ammonium hydroxide and add 0.2 ml. in excess. This usually requires 5 ml. of ammonium hydroxide. It is rather tedious to rely on the litmus endpoint because the color change in this reaction is slow. Consequently it is desirable to standardize the procedure very carefully and add the same amount of base to each sample.

After neutralization, stopper and place in a stream of running water to cool approximately to room temperature. If the solution is not alkaline after cooling, add more ammonium hydroxide.

Add 10 ml. of the carbamate solution, mix, then add 5 ml. of redistilled isoamyl alcohol accurately measured. Stopper and shake for two minutes. Allow to stand until the alcohol layer separates; then decant into an ordinary Pyrex test tube. The alcohol, poured slowly, can be transferred to the test tube, which should contain no traces of nitric acid. The presence of any acid causes a turbidity in the alcohol-carbamate extract.

Centrifuge the extract for approximately a minute to remove water from the alcohol layer. Transfer from the test tube to the absorption cell with an eye dropper, avoiding contact of the solution with the rubber bulb. The color of the extracted carbamate complex is stable, which is desirable for routine analyses.

Per cent transmission was determined with a Cenco Sheard Photelometer, using filter 87309–A. The amount of copper in samples was determined

TABLE 1

Copper in whole milk powder ashed in porcelain and Pyrex Vycor dishes

Porcelain	Pyrex Vycor
ppm. Cu	*ppm. Cu*
2.85	1.36
3.12	1.32
2.44	1.41
1.90	1.39
1.79	1.31
2.10	1.35

from a calibration curve prepared by using standard solutions of copper sulphate.

EXPERIMENTAL

The first experiments were conducted by ashing 5-gram samples of whole milk powder in porcelain crucibles. The inconsistent results obtained indicated the possibility of contamination from the crucibles, so a comparison was made between the amount of copper found in samples of powder ashed in porcelain crucibles and Pyrex Vycor evaporating dishes. The results are shown in table 1. All individual determinations reported in the various tables were made on one lot of powder, and the results for copper are reported as parts per million.

The crucibles used for ashing samples were new, and the data indicate that they were a probable source of contamination.

Table 2 shows the results of ashing samples of powder in 60-ml. porcelain evaporating dishes. Evaporating dishes were preferred to crucibles because a greater surface area of the powder was exposed to heat and ashing was more rapid. The results reported were secured by ashing 3 samples in new dishes, and six were ashed in old dishes that had been used for several years.

The porcelain crucibles (tables 1 and 2) were cleaned by heating in H_2SO_4, rinsed and then boiled in 1–1 nitric acid. After the nitric acid treatment they were thoroughly rinsed with copper-free water, dried and stored in a desiccator.

The results in table 2 indicate that the glaze on the porcelain dishes may

TABLE 2

Copper content of samples ashed in new and old porcelain dishes

New dishes	Old dishes
ppm. Cu	*ppm. Cu*
4.26	2.06
2.60	2.02
2.56	2.03
.....	2.11
.....	2.08
.....	1.97

be the cause of contamination. Elvehjem and Lindow (5) found that new porcelain dishes contained appreciable amounts of copper, and these could be used only after being properly treated.

Milk ash is alkaline, and the continual use of crucibles for ashing samples causes a slow etching. Consequently it seemed advisable to avoid the use of porcelain and use Pyrex Vycor dishes for the remainder of our studies since we had experienced no contamination from these dishes.

Wichmann (12) reported that the results on dry ashing were in doubt and that wet ashing has at least the disadvantage of undesirable high blanks. He considers a temperature of 500° too hot for ashing samples.

Gebhardt and Sommer (6) stress the importance of controlling the temperature and time of ashing. They found that no copper was lost from samples of milk which were ashed at 565° C. for three to four hours. McFarlane (10) and Ansbacher and co-workers (1) recommend an ashing temperature of 400° for approximately 12 hours.

TABLE 3

Copper content of powder ashed at various temperatures
(Results reported as ppm. Cu)

Temp. / Time—hrs.	400° C. 11	400° C. 24	500° C. 2	500° C. 5	550° C. 1	550° C. 2	550° C. 1
	2.08	1.93	2.04	1.91	2.03	1.97	1.95
	2.10	1.93	1.90	1.91	1.87	1.64	1.91
	2.04	1.95	1.98	1.90	2.03	1.82	1.93
	2.04	2.06	2.08	2.06	1.86	1.79	1.82
	2.04	1.90	1.97	1.87	1.90	1.71	1.90
	2.18	1.97	1.99	1.86	1.87	2.07	1.90
Mean	2.08	1.96	1.99	1.92	1.93	1.82	1.90

It seems logical, therefore, to believe that various organic materials require an appropriate modification in ashing procedure, depending upon the nature of the determination.

Table 3 shows the effect of ashing temperature upon the copper content of whole milk powder.

The results indicated that no copper was lost as a result of the ashing temperatures used. Ashing whole milk powder at a temperature of 400° is satisfactory, but the data indicate that no particular advantage could be attributed to the use of this temperature.

An ashing temperature of 500° was selected because samples of powder could be ashed in approximately two hours after charring on the hot plate. Also, the Vycor dishes are etched more rapidly at temperatures above 500° in the presence of the alkaline milk ash.

In order to prove that no copper is lost by ashing, recoveries were made by adding 0.01 mg. of copper to a series of samples. After the addition of copper (solution of $CuSO_4$) the samples were dried in a 100° oven, ashed and analyzed. The results are shown in tables 4 and 5.

TABLE 4

Recovery of copper in samples ashed at 400° C.

Cu found	Cu added	Cu recovered	Error
ppm.	*ppm.*	*ppm.*	
2.08	2.03	4.07	−0.04
"	1.95	4.10	+0.07
"	1.72	3.79	−0.01
"	1.83	3.83	−0.08
"	1.69	3.55	−0.22
"	2.02	4.05	−0.05

The value reported for copper found is the mean of the values reported in table 3 for ashing at 400° for 11 hours. If the value 1.96 (average of samples ashed at 400° for 24 hours) is substituted for copper found, the errors in recoveries are 0.08, 0.19, 0.11, 0.04, 0.10 and 0.07 respectively.

TABLE 5

Recovery of copper in samples ashed at 500° C.

Cu found	Cu added	Cu recovered	Error
ppm.	*ppm.*	*ppm.*	
1.99	1.81	3.63	−0.17
"	1.81	3.62	−0.18
"	2.17	4.06	−0.10
"	1.89	3.59	−0.29
"	1.70	3.57	−0.12
"	1.90	3.61	−0.28

The values reported for copper found are the mean of the results recorded in table 3 for ashing at 500° for two hours. If the value 1.92 (average copper content of samples ashed at 500°—5 hours) is substituted for copper found, the errors in recoveries are 0.10, 0.11, 0.03, 0.22, 0.05 and 0.21 parts per million.

The results in tables 4 and 5 indicate that there is no loss of copper from the samples as a result of the ashing process.

The data reported in table 6 show the copper content of whole milk powder determined by the carbamate and hydrogen sulphide methods (10).

TABLE 6

Copper content by carbamate and H_2S methods

H_2S	Carbamate
ppm.	*ppm.*
1.87	1.67
1.97	1.82
1.62	1.73
1.67	1.64
.....	1.73
Ave. 1.78	1.80

The results are in good agreement, but the H_2S method is tedious and time consuming, and not as adaptable to routine laboratory work as the carbamate procedure.

SUMMARY AND CONCLUSIONS

A routine method is described for the determination of copper in whole milk powder. The procedure has been found to be sensitive and well adapted to routine analyses.

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THE EFFECT OF VARIOUS HOMOGENIZATION PRESSURES ON THE LEUCOCYTE COUNT OF MILK*

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Adequate homogenization of milk sufficiently reduces the size of the fat globules so as to inhibit fat rising in the processed product. While the fat is the chief component of milk affected by the process, many physical and chemical changes occur in the homogenized milk which are not normal in non-homogenized milk. One of these is the settling of leucocytes and other suspended material to form a sediment. The every-other-day system of milk delivery has resulted in an increased consumer consciousness of the sediment in nonclarified homogenized milk. Under this system some of the milk not only is held longer than normally, but often some of the bottles are stored horizontally. Thus, any deposited sediment appears as a yellowish grey streak the entire length of the vertical bottle.

Since leucocytes are regarded as an important constituent of the sediment often noticed in homogenized milk, it seemed expedient to ascertain the influence of various homogenizing pressures on them, particularly to determine whether they could be disintegrated sufficiently by the process to inhibit their settling out.

INFLUENCE OF NORMAL HOMOGENIZATION PRESSURE

Leucocyte counts were made on milk before and after homogenization, using an improved Neubauer counting chamber and Toisson's fluid as a stain. The milk was pasteurized at 142° to 144° F. for 30 minutes and homogenized at pressures ranging from 2,000 to 2,500 pounds per square inch. The intensity of sediment was determined by microscopic examination. The data secured from 30 trials are presented in table 1. The data show that in all but four cases the number of leucocytes found in the non-homogenized milk exceeded the count in the homogenized milk. The inconsistency of these four trials might be explained by the fact that the counts were within the range of experimental error and occurred on relatively low count milk to which no leucocytes had been added. The reduction, based on the logarithmic average, was found to be 41.24 per cent.

The decrease in the number of leucocytes in the homogenized milk must be attributed to the destructive action of the homogenization process. No other explanation can be given, since in making the counts the leucocytes were much more easily observed in the microscopic field of the homogenized milk than of the non-homogenized milk.

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INFLUENCE OF REPEATED HIGH PRESSURE HOMOGENIZATION

Since the results of previous trials had shown that normal homogenization pressures reduced the leucocyte count in the homogenized milk, trials were made to ascertain the influence of repeated high-pressure homogenization on the leucocyte count. It was believed that high-pressure homogenization would demonstrate more fully the destructive action of homogenization.

TABLE 1

The influence of normal homogenization pressure on the destruction of leucocytes

Trial number	Leucocytes per ml. in milk when	
	Non-homogenized	Homogenized
1	3,900,000	2,320,000
2	1,620,000	480,000
3	1,440,000	760,000
4	1,140,000	1,040,000
5	1,800,000	640,000
6	1,000,000	700,000
7	1,060,000	460,000
8	880,000	700,000
9	940,000	760,000
10	2,240,000	960,000
11	640,000	440,000
12	260,000	340,000
13	100,000	120,000
14	80,000	100,000
15	180,000	100,000
16	440,000	160,000
17	160,000	100,000
18	200,000	140,000
19	120,000	180,000
20	320,000	320,000
21	140,000	120,000
22	2,260,000	580,000
23	3,000,000	1,140,000
24	4,060,000	2,160,000
25	1,460,000	700,000
26	1,900,000	560,000
27	1,580,000	460,000
28	960,000	480,000
29	1,060,000	500,000
30	800,000	480,000
Log. average	725,000	426,000

The trials were made on raw, clarified milk to which was added fresh separator slime at the rate of 1.5 gm. per quart of milk. The milk was pasteurized at 142° to 144° F. for 30 minutes and homogenized, first at 2,500 pounds pressure, then at 5,000 pounds pressure for five times. Quart samples were collected, cooled and held for 48 hours at 40° F., after which examinations were made.

The leucocyte count was decreased over 83 per cent by subjecting the milk to 2,500 pounds pressure followed by homogenizing twice at 5,000

TABLE 2

The influence of repeated high pressure homogenization on the leucocyte count and the intensity of sediment in quart bottles of homogenized milk
(Average of three trials)

Number of times homogenized	Homogenization pressure	Leucocytes	Leucocyte reduction	Intensity of sediment*
	lbs./sq. in.	*no./ml.*	*% of total*	
0	0	957,000	.....	0.0
1	2,500	625,400	34.6	3.0
2	5,000	357,200	62.7	3.0
3	5,000	159,100	83.4	3.0
4	5,000	106,300	88.9	3.0
5	5,000	84,300	91.2	3.0
6	5,000	72,700	92.4	3.0

* Key: 0.0 = no sediment.
1.0 = slight sediment.
2.0 = distinct sediment.
3.0 = pronounced sediment.

pounds (table 2, figure 1). Continued high-pressure homogenization until the milk had been homogenized five times at 5,000 pounds resulted in a maximum reduction in leucocytes of 92.4 per cent.

Although the leucocyte count decreased with repeated high pressure homogenization, no reduction in the intensity of sediment was observed. All milk showed sediment of a greyish color and was given an intensity rating of 3.0. Some difference was noticed in the general appearance of the sediment. The sediment deposits of the milk homogenized at 5,000 pounds sometimes resembled fine sand in appearance; but, with repeated high pressure, homogenization appeared smooth and even throughout. Microscopic

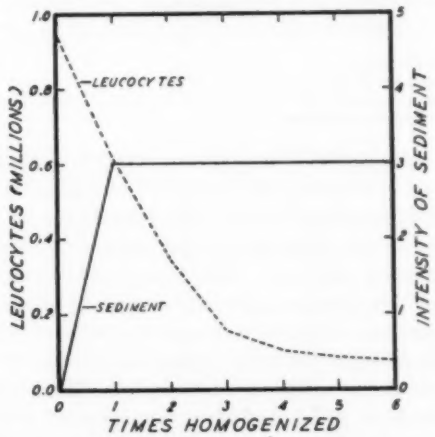

FIG. 1. The influence of repeated high pressure homogenization on the leucocyte count and on the intensity of sediment.

examinations of the sediment showed it to be composed, in large part, of fragments of leucocytes. The conclusion was reached that the broken leucocytes tended to settle down and form sediment, similarly to the nonbroken leucocytes found in milk.

INFLUENCE OF CONTINUOUS, HIGH-PRESSURE HOMOGENIZATION

The previous experiment had shown the destructive action of high pressure homogenization upon leucocytes. A trial was conducted with the purpose of attempting to accomplish their complete destruction. Fresh separator slime was added to 5 gallons of pasteurized milk at the rate of 1.5 gm. per quart. The milk was heated to 140° F. and homogenized at 5,000 pounds pressure for ten minutes continuously. Quart samples of milk were collected before and after homogenization as well as at two-minute intervals during the continuous process. All samples were cooled and held at 40° F. for 48 hours, after which examinations for sediment and leucocytes were made.

TABLE 3

The influence of continuous high pressure homogenization on the leucocyte count and on the intensity of sediment

Time homogenized	Homogenization pressure	Leucocytes per ml.	Leucocyte reduction	Intensity of sediment*
minutes	*lbs./sq. in.*		*% of total*	
Control	0	2,240,000	0.0	0.0
0	2,500	960,000	57.1	3.0
2	5,000	320,000	85.8	3.0
4	5,000	180,000	92.0	3.0
6	5,000	100,000	95.5	3.0
8	5,000	40,000	98.2	3.0
10	5,000	20,000	99.1	3.0

* Key: 0.0 = no sediment.
1.0 = slight sediment.
2.0 = distinct sediment.
3.0 = pronounced sediment.

Virtually complete destruction of leucocytes was accomplished (table 3, figure 2). The leucocyte count was reduced from 2,240,000 per ml. to 20,000 per ml. as a result of homogenizing at 5,000 pounds for 10 minutes. Microscopic examination of the homogenized milk showed the last samples to contain leucocytes of small size only. The leucocyte fragments, although not readily stained, could be seen as small particles in the microscopic field. The intensity of sediment was found to be the same in all samples of homogenized milk. This would indicate that the broken leucocytes settled and formed sediment, similarly to the nonbroken leucocytes. Microscopic examination of the sediment in milk which had been homogenized continually for ten minutes at 5,000 pounds pressure showed the sediment to consist largely of fragmentary materials.

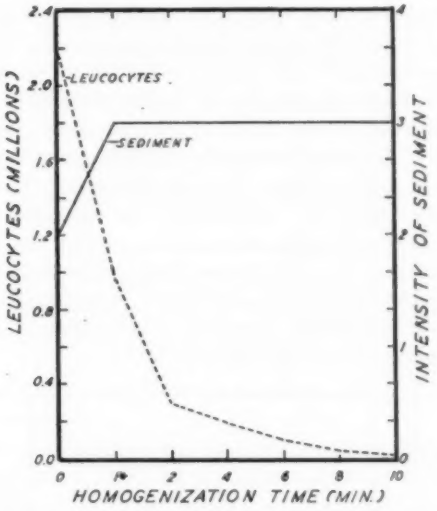

FIG. 2. The influence of continuous high-pressure homogenization on the leucocyte count and the intensity of sediment in quart bottles of homogenized milk.

* Homogenized once at 2,500 pounds pressure.

EFFECT ON SEDIMENTATION OF ADDING INCREASING PORTIONS OF CONTINUOUS HIGH-PRESSURE-HOMOGENIZED MILK TO NORMAL HOMOGENIZED MILK

Since it appeared that leucocytes could be fragmented, it seemed desirable to ascertain if mixtures of high-pressure and low-pressure homogenized milk would result in variations in the intensity of sediment.

TABLE 4

The influence of adding increasing portions of continuous high pressure treated milk to normal homogenized milk on the intensity of sediment produced

Sample number	Per cent of normal homogenized milk per bottle	Per cent of continuous high pressure treated milk per bottle	Intensity of sediment*
1	100	0	0
2	90	10	1
3	80	20	3
4	70	30	3
5	60	40	3
6	50	50	3
7	40	60	4
8	30	70	4
9	20	80	4
10	10	90	4
11	0	100	4

* Key: 0 = no sediment.
1 = slight sediment.
2 = distinct sediment.
3 = pronounced sediment.
4 = very pronounced sediment.

To a series of eleven quart bottles containing decreasing amounts of normal homogenized milk were added increasing amounts of the continuous, high-pressure homogenized milk prepared earlier in this experiment. All samples were mixed well and allowed to remain undisturbed for 48 hours at 40° F. Sediment studies were made at the end of the storage period.

The intensity of sediment increased with the addition of increasing portions of continuous, high-pressure homogenized milk. This is shown in the data of table 4 and figure 3. Apparently the sediment was not due primarily to whole leucocytes, since none of the samples contained a leucocyte count above 80,000 per ml. A high correlation seemed to exist between the intensity of the sediment and the proportion of high-pressure homogenized milk (figure 3). Undoubtedly, therefore, the settling of the broken leucocytes in normal homogenized milk occurs readily.

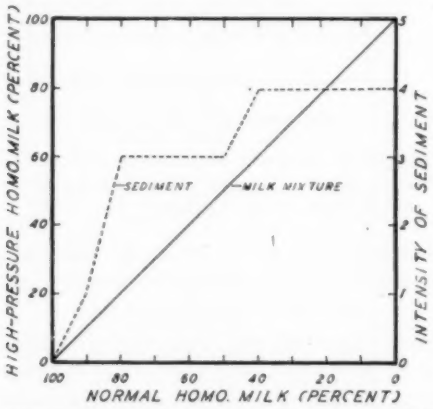

FIG. 3. The influence of adding increasing portions of continuous high-pressure treated milk to normal homogenized milk on the intensity of sediment produced.

SUMMARY

Results of 30 trials showed that homogenizing milk at 2,500 pounds pressure at 142° to 144° F. reduced the leucocyte count on an average of 41.28 per cent.

Rehomogenizing milk five times at 5,000 pounds pressure reduced the leucocyte count 92.4 per cent with little effect on the intensity of the sediment.

Milk homogenized at 5,000 pounds pressure for 10 minutes showed a reduction of leucocyte count of 99.1 per cent. The intensity of the sediment was the same in all homogenized samples.

The addition of increasing portions of high-pressure homogenized milk to normal clarified homogenized milk resulted in a corresponding increase in the intensity of the sediment in the milk mixture.

ANNOUNCEMENT

FORTIETH ANNUAL MEETING

June 12, 13, 14, 1945

IOWA STATE COLLEGE, AMES, IOWA

LAST CALL FOR PAPERS

The Program Committee urgently requests that all members who wish to present papers at the annual meeting promptly send titles and authors to the chairman of the program committee of the section before which the paper should be given. If there is doubt about the section, send the title to the general chairman. All titles must be received by April 1 and this is the final appeal for papers.

The abstracts must be received by June 1. They should be mailed to the committee chairman to whom the title was sent. It is essential that these dates be adhered to rigidly to assure the appearance of the program and abstracts on time.

Program Committee: G. W. SALISBURY, FLOYD ARNOLD, G. C. NORTH, F. E. NELSON, A. C. DAHLBERG

TENTATIVE SCHEDULE OF PROGRAM

Date	*General*	*Production*	*Extension*	*Manufacturing*
Tuesday, June 12				
9–10	Registration			
10–12	Opening session	.....	.....	.....
1– 4	.....	Papers	Papers	Papers
4– 5	Committees	Committees	Committees	Committees
7:30	Mixer			
Wednesday, June 13				
9–11	.....	Papers	Papers	Papers
11–12	.....	Business	Business	Business
1– 4	Post war dairy problems	.....	.....	.....
4– 5	Campus tours			
7:30	Reception			
Thursday, June 14				
9–11	.....	Papers	Papers	Papers
11–12	.....	Business	Business	Business
1– 3	.....	Papers	Papers	Papers
3–4:30	Business meeting	.....	.....	.....
6:30	Banquet			

VOLUME XXVIII MARCH, 1945 NUMBER 3

JOURNAL OF DAIRY SCIENCE

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Ohio State University, Columbus, Ohio

ABSTRACTS OF LITERATURE

T. S. SUTTON, Editor
Columbus, Ohio

MILK AND MILK PRODUCTS

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New York Association of Dairy and Milk Inspectors

Prussian Dairy Research Institute, Kiel, Germany

State Agricultural Colleges and Experiment Stations

The Royal Technical College, Copenhagen, Denmark

United States Department of Agriculture

ABSTRACTS OF LITERATURE

BOOK REVIEW

65. Advances in Protein Chemistry, Vol. I. M. L. ANSON, Continental Foods, Hoboken, and John T. Edsall, Harvard Medical School, Boston. Academic Press, Inc., New York, 1944.

This is the first volume of a series projected to present the most recent developments in the various phases of the chemistry of proteins. The main divisions of this book are Lipoproteins; Structural Proteins of Cells and Tissues; Some Contributions of Immunology to the Study of Proteins; The Interaction between the Alkali Earth Cations, Particularly Calcium, and Proteins; The Purification and Properties of Certain Protein Hormones; Soybean Protein in Human Nutrition; Nucleoproteins, and The Proteins of Skeletal Muscle. Each section is contributed by an author or authors especially qualified in the particular field involved. The references at the end of each section are very complete and include those of as recent publications as 1943. A feature of this book, and one which could well be followed by all editors of similar type publications, is that of presenting the complete outline of each section at its start in the body of the book. This is in addition to the usual arrangement of chapters or section outlines at the start.

Much evidence of the aids to protein chemistry investigation are shown in references to ultracentrifugation, electron microscope (EM), electron micrograph (EMG), ultrasonic fragmentation, ultrafiltration, X-ray diffraction, electrophoresis, etc. L.M.D.

BACTERIOLOGY

66. Occurrence of Enterococci in Milk. J. C. WHITE AND J. M. SHERMAN, Cornell Univ. Jour. Bact., *48*, No. 2: 262. Aug., 1944. Proc. of Local Branches.

A selective medium for the determination of enterococci from milk contains 0.5% glucose, 0.5% tryptone, 0.5% yeast extract, 1.5% agar, 0.03% sodium azide, and penicillin in a concentration of 325 Oxford units per liter. All enterococci grew quantitatively on this medium excepting *Streptococcus durans*, which was partially inhibited; and practically all of the bacteria from milk which grew on it proved to be enterococci.

From 192 samples of raw milk and 19 samples of pasteurized milk enterococci constituted 0.4% and 0.1%, respectively, of the total bacterial population. Milks which had high total bacterial counts had significantly lower percentages of enterococci, although the actual numbers were higher. The large variations in the numbers and percentages of enterococci in different

milks would appear to make the use of these organisms as an index of milk quality of doubtful value. D.P.G.

67. The Food Poisoning Micrococci. W. C. HAYNES AND G. J. HUCKER, N. Y. Agr. Expt. Sta., Geneva. Jour. Bact., *48*, No. 2: 262. Aug., 1944. Proc. of Local Branches.

It is indicated that enterotoxin production is not a specific character, but one which can be assumed by certain pathogenic micrococci. Orange pigmented types which liquefy gelatin, hemolyze red cells, produce coagulase, and generally produce acid from lactose and maltose are those which in most instances will produce gastro-intestinal toxins.

Precipitin tests with precipitates of phosphotungstic and hydrochloric acids did not specifically differentiate these food-poisoning strains from other types of pathogenic micrococci.

In determining the cause of explosive food-poisoning epidemics, the presence of a large number of orange pigmented hemolytic, coagulase-producing micrococci should be presumptive evidence that such organisms are the cause of the epidemic. D.P.G.

68. Citric Acid Fermentation by Streptococci and Lactobacilli. J. J. R. CAMPBELL AND I. C. GUNSALUS, Cornell Univ. Jour. Bact., *48*, No. 1: 71. July, 1944.

Several species of homofermentative lactic acid bacteria, cocci, and rods are shown to utilize citric acid as an energy source for growth in the absence of fermentable carbohydrate. Certain enterococci, *Lactobacillus delbrueckii*, and *Lactobacillus casei* in neutral cultures produce as main products acetic acid and carbon dioxide; formic and lactic acids and traces of acteylmethylcarbinol and ethyl alcohol are also formed. Oxidized substrates, such as citric acid, may give more information as to the potentialities of the homofermentative organisms than will the more conventional hexoses. D.P.G.

ICE CREAM

69. Shrinkage Defect in Ice Cream. Part I. DENZEL J. HANKINSON AND CHESTER D. DAHLE, Pa. State Col. South. Dairy Prod. Jour., *36*, No. 4: 17. Oct., 1944.

A mix with a composition of 13% fat, 10.5% serum solids, 15% sugar and 0.35% stabilizer was used. Samples of the ice cream stored 12–16 weeks below – 15° F. retained their original volume when evacuated to 25 inches of mercury in packages inserted in a special Anaeroid can. Shrinkage was rapid when the samples were transferred to cabinets at 0° to 10° F. but ceased almost immediately when returned to the – 15° F. room.

Quarts of ice cream in containers, with partially stripped containers and with containers completely stripped off, were stored in a cabinet for two weeks at 5° to 10° F. No appreciable loss in volume was observed, but the ice cream spread out at the lowest point at which there was no support.

Ice cream in untreated one-quart paper containers and in similar containers treated with N/5 H_2SO_4 and ethyl alcohol respectively showed about the same amount of shrinkage. Coating other containers with paraffin or with N/10 NaOH seemed to decrease the shrinkage. Shrinkage in continuous frozen ice cream was greater than in batch frozen ice cream, but at least a part of the shrinkage may have been caused by 10% higher overrun in the former. Vacuum treated samples stored in tin containers (1) lined with parchment, (2) lined with paper toweling, (3) paraffined inside, and (4) untreated, showed very little evidence of shrinkage, but marked shrinkage occurred in similar containers coated with vaseline. Samples stored in tin which were not vacuum-treated showed little evidence of shrinkage. Paraffining paper containers on the outside gave no protection against shrinkage, but paraffining on the inside had the effect of reducing shrinkage. These last results indicate that the bond between the ice cream and the container should be given consideration as an influence on shrinkage.

In other tests the stiffness of freezing had little or no effect on the amount of shrinkage.

Tests on the effect of homogenizing conditions when samples were vacuum-treated show that dual homogenization resulted in more shrinkage than single valve homogenization except when the pressure applied on the second stage valve approached that on the first stage valve. Increased pressure in either type of homogenization resulted in increased amounts of shrinkage. The samples stored in the cabinets without vacuum treatment showed no significant shrinkage tendency. F.W.B.

70. Factors Influencing Overrun in Sherbets. ALAN LEIGHTON, Division of Dairy Research, U. S. Bureau of Dairy Industry, Washington, D. C. Ice Cream Trade Jour., *40*, No. 10: 78, Oct., 1944.

A number of freezing trials were made to determine the effect of several factors on the amount of overrun obtained in sherbets. The following conclusions were made.

"The data showed that, with sherbets as with the ice cream, other factors being constant, temperature determines the amount of air that can be taken up by the freezing mass. The presence of butterfat markedly lowers the overrun obtainable in a sherbet as does an increase in the sugar content. Sherbets of low milk solids content are slow to whip in the initial stages of the freezing process."

"The data also indicate that the best method for freezing sherbets is to freeze to the lowest temperature at which the mass will run from the freezer,

accepting the overrun existing at that temperature. If the freezer is filled too full the load on the motor may be too great to permit drawing at this ideal temperature, in which case the weight of the batch must be reduced. On the other hand, it may be difficult to control temperature if the batch is too small. A careful adjustment of batch size is necessary." W.H.M.

71. Properties of Quick Frozen Cream. C. D. DAHLE AND D. V. JOSEPHSON, Pa. Agr. Expt. Sta., State College, Pa. Ice Cream Field, *44*, No. 5: 36, Nov., 1944.

Results of experimental work on frozen cream are reported in which cream frozen slowly by placing it at a temperature of $-20°$ to $-25°$ F. was compared with cream frozen rapidly by flowing a thin film over a refrigerated drum maintained at about $-20°$ to $-25°$ F. and then removing it as flakes. Both sets of samples were stored at $-10°$ to $-20°$ F. until sampled. The following determinations were made on samples thawed at room temperature: acidity, flavor, stability in coffee, "oiling off," whipping ability, and viscosity.

It was found that the freezing of cream by the quick method produced samples with normal whipping ability that exhibited little or no "oiling off." The flavor of all cream was good the first two months but after four months an oxidized flavor had developed in the fast frozen cream. Tests with ice cream showed that the fast frozen or "flake cream" did not act as an overrun deterrent, whereas the statically frozen cream did. W.C.C.

72. Low-Temperature Cabinets and Their Effect on the Frozen Food Industry. PHIL HEDRICK, Sales Engineer, Universal Cooler Corp. Ice Cream Field, *44*, No. 5: 32, Nov., 1944.

It is stated that experts predict that the first year they are released for production that about 1½ million low-temperature cabinets will be manufactured and sold.

Although the process of sharp-freezing foods is not complicated, it must be done correctly and the correct procedure varies with the food being processed and frozen. Thus it is pointed out that blanching, cooling, packaging, and freezing are all important and must be done at the proper time.

The author states that there are now over 5,000 cold-storage locker plants in the United States and that there will likely be over 6,000 by the end of the war. He predicts that most post-war home lockers, freezers, and low-temperature cabinets and farm freezers will be used for storage purposes only. He expects that the success or failure of locker operators and the locker plant operating industry will be determined by processing and service income, not locker rental income.

He states further that almost every well-known canned foods packer will also have a line of frosted foods. Equipping the wholesale and retail food

merchants to handle frosted foods will be one of the major jobs of the commercial refrigeration post-war industry it is claimed. W.C.C.

73. **Low Price Package.** VINCENT M. RABUFFO, Editor. Ice Cream Trade Jour., *40*, No. 10: 54. Oct., 1944.

In reply to the question "Do you believe that each manufacturer should market a special low price pint containing ice cream of a lower fat content designed for low-income groups?" an overwhelming majority of the reporting manufacturers said that they were opposed to the idea. They pointed to industry's campaign on nutrition and said such a package would jeopardize the good that is being done by such a campaign. W.H.M.

74. **Merchandizing and Packaging for Locker Plants.** NEAL BANTER, Sales Maanger. Lindly Box and Paper Co., Ice Cream Field, *44*, No. 5: 40, Nov., 1944.

The author stresses the vitamin content of frozen foods and the advantage this offers in advertising, but also points out the necessity of keeping costs at a reasonable value if consumption is to reach expectations. He emphasizes consumer quality and states that it is dependent upon: (1) quality product; (2) quality processing, and (3) quality packaging. He predicts that the chain store, the department store, and the super service station of certain oil companies will compete with the locker operator for the market of packaging supplies. W.C.C.

75. **How to Merchandize Frosted Foods.** CARL SEABERGH, Pres. Frostar Frozen Food Centers, Inc. Ice Cream Field, *44*, No. 5: 30, Nov., 1944.

It is stated that picking out the right foods to "push" is probably the most important single phase of selling frozen foods. The author advises pushing (1) items on which a full profit is made, (2) foods that people will eat frequently, and (3) foods that are choice in quality. W.C.C.

76. **Locker Plants.** C. G. HICKS, Editor. Ice Cream Trade Jour., *40*, No. 10: 76, Oct., 1944.

Many ice cream manufacturers are considering the possibility of going into the food locker plant business. This would appear to be natural since the ice cream plant has the facilities for handling zero storage and has had experience in handling frozen foods. However the food locker business is tending towards a highly specialized type of business which in addition to fruit and vegetable processing, offers its patrons meat slaughtering, processing and packing, the handling of all types of fowl, packaging materials for home use and brokerage service for buying meats, poultry and fish—and,

post-war, the service should also include the sale of home holding units and deep freezers.

Each ice cream manufacturer will have to decide on the advisability of getting into the locker business. If he decides to do so there are several things which must be considered. One important consideration is the location. The best location, according to those who have had experience in building locker plants, is in a rural community in an area where, for about a twenty-mile radius, the people raise at least 75 per cent of the food supply including meat, poultry and fish. As long as the war lasts it will be necessary to file with the War Production Board an application for permission to build. The cost varies, a 533 locker plant in New Jersey cost $40 to $45 per locker to install. The rental also varies, in the East it ranges from $16.50 to $21.50 per year, and in the Middle West it may be as low as $12.50 per locker. Another factor in the success of the locker plant is some type of promotion and advertising program to build good will and acceptance in the community. W.H.M.

77. **Meeting Today's Problems in Chocolate Ice Cream.** B. I. MASUROVSKY, Editor. Ice Cream Trade Jour., *40*, No. 10: 90, Oct., 1944.

Limited supplies of cocoa beans have made it necessary for ice cream manufacturers to stretch their available supply of chocolate flavor as far as possible. In some instances the amount of cocoa used has been reduced from 4 to 3 or 2 per cent, to produce a light-colored mild-flavored chocolate ice cream. For making ice cream pops, 10 per cent of vegetable fat has been added to chocolate coating to make it go further. When chocolate flakes or sweet chocolate pieces are used some allowance should be made for the difference in composition from that of cocoa and chocolate liquor. Some of these products contain 45% sugar, 35% cocoa butter, and 20% cocoa solids and due allowance should be made for these constituents when used in the ice cream mix. Caution is also given against the use of products made from low-grade cocoa beans or blends of beans which are high in tannins. Tannic acid may destabilize the proteins in the mix and affect the gelatine.

W.H.M.

78. **Post-War Package Survey.** VINCENT M. RABUFFO, Editor. Ice Cream Trade Jour., *40*, No. 10: 44, Oct., 1944.

The volume of ice cream sold in factory-filled packages has increased during the past 2 years. A survey of representative plants in all sections of the country just completed by the Ice Cream Trade Journal indicated that the average volume of ice cream sold by all the reporting plants in packaged form increased from 23.89 per cent in 1941 to 27.62 per cent in 1943 and to 28.9 per cent during the first 7 months of 1944. An increase was reported for every section of the United States except in the Middle West.

where a decrease was noted in 1944. One of the factors contributing to this increase obviously was the fact that factory-filled packages made it possible for the ice cream manufacturer to market a substantial part of his volume as sherbets with less sales resistance than existed for sherbets in bulk form. Other contributing factors mentioned were, a saving in labor in selling at the dealer's store and packages made it possible for the dealer to stock a greater variety of flavors. On the other hand difficulties in securing packages and packaging equipment repair parts and plant labor to fill them, may have prevented even a greater trend towards packaged ice cream.

Over 90 per cent of the manufacturers replied in the affirmative to the question, "Do you believe there will be a marked increase in package sales after the war?" These manufacturers rated in the following order the importance of certain factors which would affect the increase. 1. Larger low temperature compartments in household refrigerators. 2. The sale of ice cream by food stores, and 3. The home freezer and storage cabinets which are expected to be a part of the household equipment in many homes after the war. W.H.M.

79. Package Prices. VINCENT M. RABUFFO, Editor. Ice Cream Trade Jour., *40*, No. 10: 52. Oct., 1944.

Returns from 73.27 per cent of the reporting companies in Ice Cream Trade Journal Survey stated that dealers were paying more for packaged ice cream than for bulk. A majority (58.52 per cent) indicated that packaged ice cream brought 15 to 20 per cent more than bulk. Others indicated a lower percentage. 4.78 per cent indicated that they received the same price for bulk and packaged ice cream. A majority of manufacturers who reported did not think that increased package sales would bring about a lower price. They felt that any economizing should be converted into improved quality. There were several (17.04 per cent) who thought that the price of packaged ice cream should be lowered if ice cream is to have its proper place in the home. C.D.D.

80. Sherbets in Packages. VINCENT M. RABUFFO, Editor. Ice Cream Trade Jour., *40*, No. 10: 50. Oct., 1944.

The 1944 Ice Cream Trade Journal's Post-War Package Survey on the sale of sherbets in packages showed that 90.26 per cent of the reporting companies were incorporating sherbets and ices in all or part of their package line. The main reasons for the sherbet and ice cream combination were that it augmented quotas and that it had sales appeal. The manpower shortage and customer objections to sherbets and ices were the main reasons cited for not making the combination package.

The amount of sherbets and ices used in combination with ice cream ranged from 15 per cent to 75 per cent with an average of 40 per cent for

the entire group. Most companies reported that they used 33 per cent of sherbet in the combination package. The majority (59.12 per cent) of the reporting companies indicated that they intended to continue to put out a combination package after the war. A majority (53.95 per cent) also stated that they did not intend to put out a 100 per cent sherbet package with a marked price differential after the war. There was a substantial portion of reporting companies who thought that a market exists for a 100 per cent sherbet package after the war on a price basis. W.H.M.

81. Frozen Foods Packages. C. G. HICKS, Ice Cream Trade Jour., *40*, No. 11: 40. Nov., 1944.

With the possibility of an increase in the number of retail outlets which will handle frozen foods after the war, food processors are turning their attention to improved storage cabinets and packages. The storage cabinets will be of the self-selection, display type rather than the present kind which keeps the merchandise buried out of sight of the customer.

Packages too will be improved and made more attractive. At present most frozen food packages consist of a cellulose-film-lined, rectangular, treated, paperboard carton about 5 inches long, 4 inches wide and 1 3/16 to 1 7/8 inches high. The packages are usually overwrapped with wax paper. Although present-day packages are fairly satisfactory, manufacturers are agreed that there is room for further improvement. Here are some of the features which should characterize the frozen foods package of tomorrow. "Undoubtedly a rectangular package will always be used by the frozen food industry and the ideal, or ultimate package, might well be transparent and should be made from materials not affected by water or juices, or temperatures as low as 30° F. It should be flexible enough to withstand pressure without detrimental distortion, should close tightly to prevent leaking or desiccation of the product and it should be practically impervious to the transmission of moisture vapors. It should be relatively easy to manufacture and be readily handled automatically during production and, very important, the ultimate cost should be comparatively low, since speedy quality production is the aim." W.H.M.

MISCELLANEOUS

82. Inst. of Food Technol., 1944 Proceedings. The Garrard Press, Champaign, Illinois.

The emphasis of the proceedings as evidenced in the papers presented was about equally divided between Food Technology in War, Post-war Technology, and Technological Developments in Food Processing. Representatives of the armed forces told of problems in food shipment, preservation and consumption which have arisen in the various war theatres and how

many of those problems have been met and solved. Dairy products appear here and there in the discourses. All kinds of spoilage occurred with evaporated milk in the South Pacific area posing some processing improvements by the manufacturers in the United States. Obviously dehydrated foods are prominently present in the discussions.

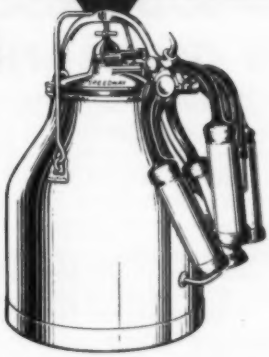
The most important paper from the standpoint of the dairy industry was, Deaeration of Liquid and Semiliquid Foods, presented by Horace L. Smith, Jr., Research Engineer, Chain Belt Company, Milwaukee, Wisconsin. The operation of the microfilm deaerator is described and detailed results from the deaeration of market milk are given showing the retention of Vitamin C in pasteurized milk and its freedom from oxidized flavor. A plan view diagram (Fig. 5, p. 78) is included giving the complete hookup for deaeration of milk in a HTST pasteurization system. The deaerator is placed between the preheater and the pasteurizing heater. (The author unfortunately labels the figure "flash pasteurization" which would be all right if citrus juice was the product.) It is stated that milk judges have compiled a list of 55 descriptive terms, many of them of colorful nature, to indicate flavor defects of milk. (It would be a worthwhile project for the American Dairy Science Association to standardize milk flavor terminology to a minimum number of terms many of which could be all-inclusive such as oxidized and hydrolized to cover various stages of milk fat deterioration with qualifications of very slight, slight, pronounced, and very pronounced. Also eliminate the term cooked when used in describing raw milk flavor.)

It is pointed out that while deaeration of milk can be beneficial in its results on milk flavor quality certain temperature conditions must be controlled in order to prevent such physical defects as partial churning, partial homogenization, and excessive foaming. Simplicity of operation and low cost are claimed. L.M.D.

Both ARE NEEDED FOR BEST RESULTS

FAST *and* **UNIFORM MILKING**

DE LAVAL MAGNETIC *SPEEDWAY* MILKER



Only the De Laval Magnetic Speedway Milker provides *both* uniform and fast milking . . . and both are essential.

Uniform milking . . . gets the highest milk yield at every milking . . . and throughout the entire lactation period and lifetime of the cow. Change in milking speed and action lowers production . . . as demonstrated when hand milkers are changed.

Fast milking . . . with proper cow preparation . . . results in healthier udders . . . time savings . . . better production . . . less strippings and cleaner milk.

In the De Laval Magnetic Speedway Milker pulsations are controlled by magnetic force from the Pulso-Pump . . . all units milk with the same uniform speed and action at all times.

Best milking means best results . . . and that's the kind of milking you want.

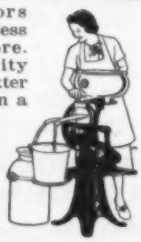
EFFICIENCY PAYS

Further improve your results by following the new 1945 National 8-Point Dairy Program jointly sponsored by the Extension Service and the Dairy Industry Committee.

DE LAVAL STERLING MILKER

The De Laval Sterling Milker is a worthy companion to the great De Laval Magnetic Speedway Milker and is particularly adapted for those to whom lower price is an important consideration. The Sterling Pulsator has only two moving parts, gives positive milking speed and action. De Laval Sterling single or double units may also be used on any other make of single pipe line installation.

DE LAVAL SEPARATORS



De Laval Cream Separators skim cleaner, last longer, cost less per year of use and earn more. They produce highest quality cream for highest quality butter and may easily be washed in a few minutes' time under ordinary farm conditions. De Laval Separators are made in a wide variety of sizes and styles and at prices to meet every need and purse. Hand or motor drive.

THE DE LAVAL SEPARATOR COMPANY

NEW YORK 6 — 165 BROADWAY
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SAN FRANCISCO 19 — 61 BEALE ST.

Your advertisement is being read in every State and in 25 Foreign Countries

Do You Know YOUR GEOGRAPHY?

You'd be surprised how tricky the map can be. Many people get mixed up on two of these questions—but a national survey showed that 8 out of 10 people can answer the third. (Turn the page for the answers.)

(a) **Which of these cities, at the ends of the Panama Canal, is further west?**
Colon, at the Atlantic end ☐
Panama, at the Pacific end ☐

(b) **If you flew directly south from Tampa, Florida, in what part of South America would you eventually land?**
In Rio de Janeiro, Brazil ☐
In Lima, Peru ☐
Miss it completely ☐

(c) **In which part of the United States is dextrose recognized as food-energy sugar by more people (per 1000)?**
Portland, Maine ☐
Portland, Oregon ☐

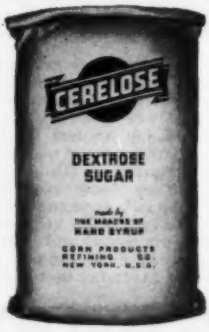
ANSWERS

(a) The Atlantic end of the Canal is west of the Pacific end.

(b) You'd wind up in the Pacific Ocean.

(c) 8 *out of 10* people everywhere know that dextrose is food-energy sugar —thanks to consistent educational advertising.

CORN PRODUCTS SALES COMPANY
17 BATTERY PLACE
NEW YORK 4, N. Y.

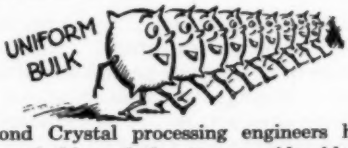


CERELOSE is dextrose

"Whad'ya Know, Brother, About BULK?"

EVERY TECHNICAL man is supposed to know his own field thoroughly and have a general idea of related technical fields. But few food processors have time to develop more than a sketchy knowledge of these related subjects.

Take the bulkiness of salt—the specific gravity —which may vary rather widely. A survey of various salt products from different sections of the country has shown that even salt of the same grade can vary up to 25% in bulkiness over a period of months.



Diamond Crystal processing engineers have eliminated this variation to a considerable extent through rigid control of crystallizing conditions and the most modern screening methods. Thus the various grades of Diamond Crystal Salt will not vary more than 4% plus or minus —usually not over 2%.

If you, as a food processor, are applying salt by volume—through a hopper, for example, as in salting soda crackers, potato chips, etc.—you can only achieve flavor control by using a salt that varies little in bulkiness. Why not check the density of each shipment of salt you are using and see how much it varies in bulk?

NEED HELP? HERE IT IS!

If this is the solution to that variable-flavor problem, write our Technical Director. He will be glad to help you find a cure. Diamond Crystal, Dept. H-5, St. Clair, Michigan.

DIAMOND CRYSTAL
ALBERGER PROCESS **SALT**

Your advertisement is being read in every State and in 25 Foreign Countries

New Slant on CALF SCOURS

Extensive research at the Wisconsin Agricultural Experiment Station shows that most cases of calf scours are due to a dietary deficiency. The contributing factors are vitamin A and niacin. The same formula used in the Wisconsin studies for preventing and curing nutritional scours has been employed in ANADEX Kaf-Kaps.

Daily use of ANADEX for the first few weeks is helping dairymen save calves from scours and attendant disorders. Calves on skimmilk diets receive in ANADEX adequate vitamin A till they are eating freely of hay and grain. The niacin requirements are supplied till the calf begins to synthesize this nutrient. In addition adequate vitamin D is provided for rapid growth and strong skeletal development.

ANADEX Kaf-Kaps are 10 minim (⅔ cc) capsules. Easy to administer . . . no loss in feeding or in potency. It requires about 25 Kaps per calf, at a cost to the dairyman of 73¢ to $1.00 depending on size of package. Inquiries invited.

NUTRITION PRODUCTS CO.
AURORA, ILLINOIS

FLAV-O-LAC FLAKES

THE CULTURE of definitely better flavor & aroma-producing qualities.

The standard with foremost operators, agricultural schools & colleges.

FLAV-O-LAC FLAKES (shown) produce a quart of the finest starter on a single propagation. Single bottles $2.00.

SPECIAL FLAV-O-LAC FLAKES "40" produce 40 quarts of starter on a single propagation. Single bottles $3.00

Free Culture Manual of Fermented Milk Products on request.

Pioneers in Spectro-chemical, Chemical and Fluoro-photometric Determinations of Vitamins A, B_1, B_2, Nicotinic Acid, Pantothenic Acid, B_6, C & E in Dairy and Food Products. (Vitamin D excluded) inquiries invited.

THE DAIRY LABORATORIES
23rd & Locust Sts., Phila., Pa.
DIVISION DALARE ASSOCIATES
BRANCHES
New York Baltimore Washington
See our catalog in Dairy Industries Catalog.

Our bulletin 30c is fully descriptive—Write for it.

"THE GAULIN TWO STAGE HOMOGENIZER AND HIGH PRESSURE PUMPS have met the Dairy Industries needs for a durable, heavy duty and economical machine, since 1909. Homogenizers and Pumps are still available with proper priority ratings, as well as repair and replacement parts. Both machines are strictly sanitary and are approved by all leading health boards. The Homogenizers are built in sizes from 75 gallons to 2000 gallons per hour, and the High Pressure Pumps are custom built to suit individual needs. The Gaulin is the ideal, all-purpose machine for fluid milk, ice cream, evaporated milk, condensed milk and spray-drying milk or eggs."

MANTON-GAULIN TWO STAGE HOMOGENIZER

THE MANTON-GAULIN MFG. CO., INC.
7 CHARLTON STREET EVERETT, MASS., U.S.A.

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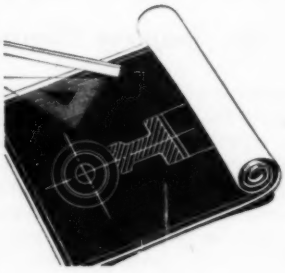
The American Dairy Science Association was organized to advance the general welfare of the dairy industry, especially by the improvement of dairy instruction by the stimulation of scientific research in all phases of the subject and by improvement in methods of conducting extension work.

Membership. Any person is eligible to membership who is formally announced by an Agricultural College or Experiment Station, or by the Bureau of Dairy Industry of the United States Department of Agriculture or by the Canadian Department of Agriculture as an instructor, extension worker, investigator, or administrative officer connected with the dairy industry, or any person filling a position of responsibility connected with the dairy industry who has had a college or university training in technical science, or any person filling a responsible position in the dairy industry of a professional character requiring a technical knowledge of dairying of a high order. The membership fee is $5.00.

The dues are $5.00 a year, $3.00 of which is for a year's subscription to the *Journal of Dairy Science*. Correspondence regarding membership and dues should be addressed to R. B. Stoltz, Ohio State University, Columbus, Ohio.



Tomorrow's BLUEPRINTS

The lessons R. G. Wright engineers and craftsmen have learned from the improved techniques of design, and production of implements of war, are being applied to good advantage in producing greatly improved R. G. Wright dairy equipment.

In fact, we are *now* again prepared to discuss any problems regarding dairy equipment. Our technical experience is at your service at all times. We'll be glad to answer any questions you may have.

R. G. Wright Company, Inc.

BUFFALO 14, N. Y.

Can Washers . . Bottle Washers . . Pasteurizers . . Surface Coolers . . Weighing and Receiving Equipment . . Sanitary Pumps . . Conveyors and Other Milk Plant Equipment.

"HANSEN'S"

Dairy Preparations

Cheese Rennet and Color
Annatto Butter Color
Certified Butter Color
Ice Cream Color
Lactic Ferment Culture
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Odorless Dairy Fly Spray
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CHR. HANSEN'S LABORATORY, INC.
MILWAUKEE, WISCONSIN

Low pH of OAKITE BACTERICIDE Speeds Bacteria Killing!

Oakite Bactericide is a scientifically designed germicidal agent possessing unusually effective bacteria-killing properties. Proof of this lies in the fact that Oakite Bactericide is almost neutral in character . . . solution pH is between 7 and 8.

The extremely low alkalinity of Oakite Bactericide permits a more rapid release of its available chlorine content. This stepped-up potency assures the user of more certain sanitation . . . more effective deodorization. It helps expedite germicidal treatment measures.

Oakite Bactericide is fully discussed in booklet form. Formulae and directions are given. Copies may be had FREE on request.

OAKITE PRODUCTS, INC.,
Dairy Research Division,
16G THAMES STREET, NEW YORK 6, N. Y.
Technical Service Representatives Located in All Principal Cities of the United States and Canada

OAKITE CLEANING

Your advertisement is being read in every State and in 25 Foreign Countries

Marschall

RENNET and COLOR

For best results in the cheese vat, specify Marschall's. High in strength, pure and uniform.

MARSCHALL
DAIRY LABORATORY, INC.
MADISON 3, WISCONSIN

Clean Separator in 2 Minutes with

KLEER-MOR

The Soapless Cleaner

Kleer-Mor is a scientifically balanced cleaner for rapid and effective hand washing operations, especially separators. Kleer-Mor has the best properties of soap, but it is entirely soapless. It quickly penetrates grease and fats and emulsifies them. It rinses readily and leaves no fatty residues or grease rings. With Kleer-Mor anyone can thoroughly clean a separator in 2 minutes. Other equipment is also as quickly and easily cleaned. Kleer-Mor will not harm equipment or roughen the hands. Packed in convenient containers for use in your own plant and on the farms of your patrons. Write for details.

KLENZADE PRODUCTS, INC.
Beloit, Wisconsin

DIET AND HEALTH

★ **The National Dairy Council is the educational and sales promotional organization of the dairy industry. The Council operates nationally through its central office in Chicago and locally through its more than thirty unit Councils in all parts of the United States.**

The National Dairy Council program reaches every member of the family through the chief opinion-forming groups in all professional and educational fields. Such key groups as physicians, dentists, teachers, nurses, nutritionists, writers and public health workers are kept informed constantly of the dietary importance of all dairy products.

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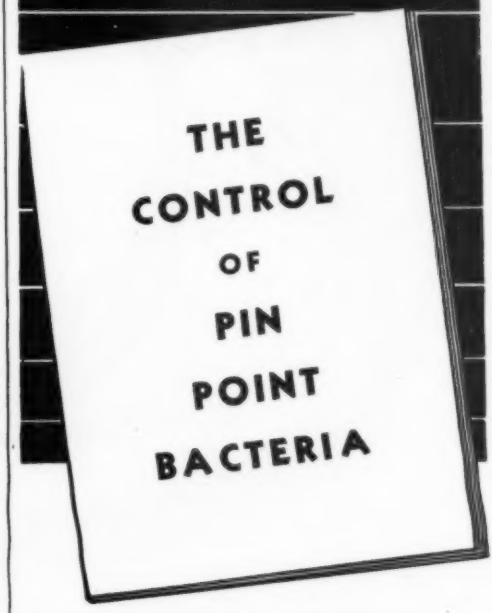


Summary of Contents

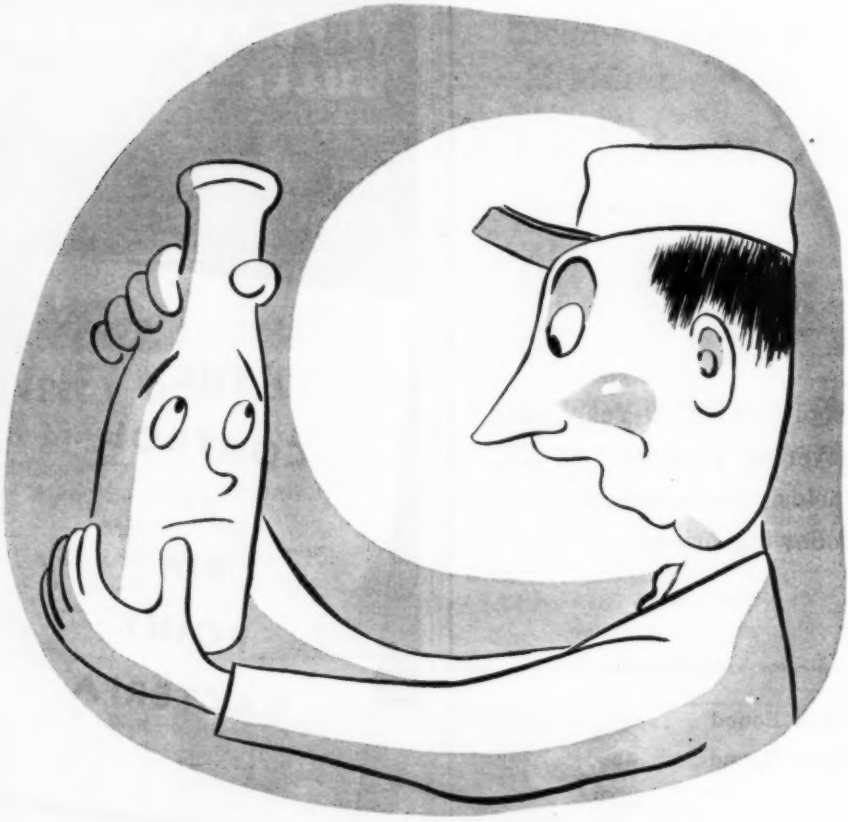
Why called "pin point" bacteria . . . .thermoduric bacteria . . . thermophilic bacteria . . . source of pin point bacteria . . . control on the farm . . . control in the plant . . . disinfecting of milk cans . . . why re-pasteurization should be avoided . . . dead ends . . . foam . . . refrigeration of pasteurized milk . . . importance of milkstone control . . . disinfecting of plant equipment.

Diversey Technical Bulletins have been prepared in the interest of better sanitation in the nation's dairy, beverage, and other food plants. Copies are available without cost or obligation. Simply address your request to The Diversey Corporation, 53 W. Jackson Blvd., Chicago.

WIN THE WAR WITH FOOD

NEED HELP? JUST CALL A DIVERSEY D-MAN

Your advertisement is being read in every State and in 25 Foreign Countries



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Clean bottles do *their* part in dairy work. They deliver your product to the consumer just as you put it in them. You can look your bottles in the eye if you have treated them right by using the alkali best suited to your washing and water conditions.

One of Wyandotte's bottle-washing alkalies — Wyandotte Alkali Special, S.I. Flakes,* Seneca Flakes* or Chippewa Flakes* — is sure to fit your plant conditions. Wyandotte B.W.C. (Bottle Water Conditioner) is for extremely hard water.

*Registered trade-mark

As the final rinse or spray, after washing, there's Wyandotte Steri-Chlor,* the dependable germicide. Safe and easy to use, it makes an absolutely clear solution.

And for general dairy equipment cleaning you have Wyandotte G.L.X.* This speedy cleaner, an excellent water softener, leaves no film or streak.

Your Wyandotte Representative, backed by Wyandotte research, has the training and experience to help you solve your cleaning problems. Call him at any time.

WYANDOTTE CHEMICALS CORPORATION • J. B. Ford Division
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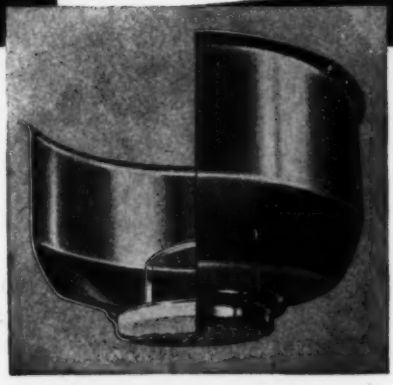
New CP 16 QUART STRAINER



One-piece—seamless construction plus hot dipped tinning and high polish insure complete sanitation and quick, easy cleaning. New, wide radius near bottom of bowl gives plenty of room for hand to place and center disc without touching side of strainer. Takes any standard make of 6½" filter disc.

Order from your nearest CP Sales Branch

Two views of CP Dome-Type Disc Retainer

THE CREAMERY PACKAGE MFG. COMPANY 1243 W. Washington Blvd., Chicago 7, Ill.
Branches in 18 Principal Cities

WHEN YOU NEED FILTER DISCS . . . CP HAS THEM

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DIFCO

Detection of
Coliform Bacteria

BACTO–BRILLIANT GREEN BILE 2%

is recommended for the detection of coliform bacteria. This medium conforms in every way to the brilliant green lactose peptone bile described in the current of "Standard Methods for the Examination of Dairy Products" and in "Standard Methods of Water Analysis of the American Public Health Association. Results obtained by the direct inoculation of water, milk and dairy products or other food materials into fermentation tubes of this medium are reliable and accurate.

BACTO–FORMATE RICINOLEATE BROTH

is also employed for the detection of coliform bacteria. The medium is used in fermentation tubes which are inoculated directly with the sample or dilution, Bacto-Formate Ricinoleate Broth conforms to the "Standard Methods" formulae.

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is recommended in "Standard Methods for the Examination of Dairy Products" for the direct plate count of the coliform bacteria. This medium is especially prepared for direct enumeration of coliform bacteria in water, milk and other dairy or food products. Upon plates of medium prepared from this product subsurface colonies of the coliform type are generally surrounded by a reddish zone of precipitated bile. Due to the inhibitory action of the medium toward other types accurate counts are obtained after incubation for only 18 hours.

Specify "DIFCO"

THE TRADE NAME OF THE PIONEERS
In the Research and Development of Bacto-Peptone and Dehydrated Culture Media

DIFCO LABORATORIES
INCORPORATED
DETROIT 1, MICHIGAN

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